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FORTY-THIRD ANNUAL REPORT

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OF THE

**NORTH CAROLINA AGRICULTURAL
EXPERIMENT STATION**

CONDUCTED JOINTLY BY THE

North Carolina Department of Agriculture

AND THE

**North Carolina State College of
Agriculture and Engineering**

FOR THE

YEAR ENDED JUNE 30, 1920

FORTY-THIRD ANNUAL REPORT

OF THE

**NORTH CAROLINA AGRICULTURAL
EXPERIMENT STATION**

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North Carolina Department of Agriculture

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**North Carolina State College of
Agriculture and Engineering**

FOR THE

YEAR ENDED JUNE 30, 1920

LETTER OF SUBMITTAL

RALEIGH, N. C., June 30, 1920.

*To His Excellency, T. W. BICKETT,
Governor of North Carolina.*

SIR:—I have the honor to submit herewith report of the operations of the Agricultural Experiment Station, conducted jointly by the North Carolina Department of Agriculture and the North Carolina State College of Agriculture and Engineering, for the year ended June 30, 1920. This work is under the immediate direction of the "Joint Committee for Agricultural Work," provided for in chapter 68 of the Public Laws of 1913, and amended by chapter 223 of the Public Laws of 1917, and the report is made in accordance with the requirements of the act of Congress, approved March 2, 1887, and known as the Hatch Act.

Very respectfully,

B. W. KILGORE,
Director.

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*GOVERNOR T. W. BICKETT, *Chairman.*

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R. W. SCOTT.....	Haw River	A. CANNON.....	Horse Shoe

STAFF OF THE NORTH CAROLINA AGRICULTURAL EXPERIMENT STATION AND EXTENSION SERVICE

ADMINISTRATION

B. W. KILGORE.....	Director of Experiment Station and Extension Service
C. B. WILLIAMS.....	Vice-Director Experiment Station
R. W. COLLETT.....	Assistant Director, Branch Station
R. W. GREEN.....	Agricultural Editor
A. F. BOWEN.....	Bursar
Miss S. D. JONES.....	Bursar
Miss MARY S. BIRDSONG.....	Secretary to director
H. C. EVANS.....	Auditor and Executive Assistant

AGRONOMY

C. B. WILLIAMS.....	Chief in Agronomy	†W. E. HEARN.....	Soil Survey
W. F. PATE.....	Soil Agronomist	†S. O. PERKINS.....	Assistant in Soil Survey
S. K. JACKSON.....	Assistant in Soils	S. F. DAVIDSON.....	Assistant in Soil Survey
H. B. MANN.....	Assistant in Soils	W. A. DAVIS.....	Assistant in Soil Survey
R. Y. WINTERS.....	Plant Breeding Agronomist	†R. E. DEVEREUX.....	Assistant in Soil Survey
S. W. HILL.....	Assistant in Plant Breeding	W. D. LEE.....	Assistant in Soil Survey
P. H. KIME.....	Assistant in Plant Breeding	†E. H. MATHEWSON.....	Tobacco Expert
G. M. GARREN.....	Assistant in Plant Breeding	A. R. RUSSELL.....	Assistant in Field Experiments
†M. W. HENSEL, Specialist in Sugar Plant Production			

CHEMISTRY

W. A. WITHERS.....	Chemist	W. G. HAYWOOD.....	Fertilizer Chemist
J. K. PLUMMER.....	State Chemist	E. S. DEWAR.....	Assistant Chemist
F. W. SHERWOOD.....	Assistant Chemist	G. L. ARTHUR.....	Assistant Chemist
J. M. PICKEL.....	Feed Chemist	B. C. WILLIAMS.....	Assistant Chemist

ENTOMOLOGY

FRANKLIN SHERMAN, JR.....	Chief in Entomology	†C. L. SAMS.....	Bee-keeping
Z. P. METCALF.....	Entomologist	W. B. MABEE.....	Extension Entomologist
R. W. LEIBY.....	Assistant Entomologist	C. S. BRIMLEY.....	Assistant Entomologist
V. R. HABER.....	Assistant Entomologist	T. D. MITCHELL.....	Assistant Entomologist

HORTICULTURE

C. D. MATTHEWS.....	Assistant Horticulturist	L. H. NELSON.....	Assistant Horticulturist
Acting Chief, Division of Horticulture		J. M. DYER.....	Assistant Horticulturist
J. P. PILLSBURY.....	Horticulturist	P. T. SCHOOLEY.....	Extension Horticulturist
L. R. DETJEN.....	Assistant Horticulturist		

ANIMAL INDUSTRY

DAN T. GRAY.....	Chief in Animal Industry	JOHN E. IVEY.....	Asst., Poultry Investigations
R. S. CURTIS.....	Associate in Animal Industry	†F. R. FARNHAM.....	Assistant in Dairy Farming
STANLEY COMBS.....	Dairy Experimenter	†A. C. KIMREY.....	Assistant in Dairy Farming
B. F. KAUPP.....	Poultry Investigator and Pathologist	†D. R. NOLAND.....	Assistant in Dairy Farming
†J. A. AREY.....	Dairy Farming	†F. T. PEDEN.....	Assistant in Beef Cattle
†W. W. SHAY.....	Swine Extension	EARL HOSTETLER.....	Assistant in Beef Cattle and Swine
A. G. OLIVER.....	Poultry Extension	†GEORGE EVANS.....	Assistant in Sheep Extension
E. C. WARDIN.....	Asst., Poultry Investigations	J. O. HALVERSON.....	Nutrition Specialist

PLANT PATHOLOGY

F. A. WOLF.....	Plant Pathologist	S. G. LEHMAN.....	Assistant in Bacteriology
	R. A. JEHL.....	Extension Pathologist	

DRAINAGE

†H. M. LYNDE.....	Senior Drainage Engineer	F. O. BARTEL.....	Junior Drainage Engineer
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VETERINARY

W. C. REEDER.....	Veterinarian, Extension
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MARKETS AND RURAL ORGANIZATION

GORRELL SHUMAKER.....	Marketing Fruits and Vegetables
J. H. HENLEY.....	Credit Unions
†P. H. HART.....	Cotton Grading
†J. P. BROWN.....	Warehouse Inspection and Operation
†J. M. WORKMAN.....	Warehouse Construction

FARM MANAGEMENT

†J. M. JOHNSON.....	Farm Management
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BRANCH STATIONS

F. T. MEACHAM.....	Assistant Director, Iredell Branch Station
C. E. CLARK.....	Assistant Director, Edgecombe Branch Station
E. G. MOSS.....	Assistant Director, Granville Branch Station
S. C. CLAPP.....	Assistant Director, Buncombe Branch Station
A. S. CLINE.....	Assistant Director, Black Land Branch Station
R. W. COLLETT.....	Assistant Director, Pender Branch Station

FARM FORESTRY

H. B. KRAUSZ.....	Farm Forestry Specialist
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FARM ENGINEERING

E. R. RANEY.....	Farm Machinery, Extension
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FARM DEMONSTRATION WORK

C. R. HUDSON.....	State Agent
H. H. B. MASK.....	Assistant State Agent
E. S. MILLSAPS.....	District Agent, Piedmont District
T. D. MCLEAN.....	District Agent, Central District
J. M. GRAY.....	District Agent, Mountain District
O. F. MCCRARY.....	District Agent, Northeastern District
E. W. GAITHER.....	District Agent, Southeastern District

HOME DEMONSTRATION WORK

MRS. JANE S. MCKIMMON.....	State Home Demonstration Agent
MISS LAURA M. WINGFIELD.....	Assistant State Home Demonstration Agent
MRS. EUNICE P. MCCRARY.....	Tidewater District Agent
MRS. ESTELLE T. SMITH.....	Eastern District Agent
MRS. CORNELIA C. MORRIS.....	Central District Agent
MISS MAUDE E. WALLACE.....	Piedmont District Agent
MRS. MITTIE M. HENLEY.....	Mountain District Agent

The members marked with * are members of the Joint Committee for Agricultural Work, and the Station is under their direction.

†In cooperation with the United States Department of Agriculture.

FORTY-THIRD ANNUAL REPORT

OF THE

North Carolina Agricultural Experiment Station

B. W. KILGORE, *Director*

During the year covered by this annual report the Experiment Station felt the effects of the readjustments going on throughout the country, and in common with other institutions suffered from the lack of funds necessary to meet the rising costs of conducting experimental work. A number of separations from the staff occurred, the men going to other institutions or into commercial work at increased salaries.

Under these conditions the development of new lines of work was impossible, although every effort was made to continue lines of experimental work already under way, and considerable progress has been made, despite the handicaps under which the Experiment Station has operated.

CHANGES IN STAFF

Since the last annual report changes in staff were made as follows:

Resignations.—E. C. Brintnall, assistant in dairy farming; J. W. Schloss, assistant in beef cattle; S. J. Kirby, assistant in plant breeding; S. G. Rubinow, assistant to the Director; F. H. Jeter, agricultural editor; Charles S. Jones, specialist in marketing livestock; Bolling Hall, assistant in marketing fruits and vegetables; A. N. Pratt, assistant in marketing perishables; R. W. Collett, assistant director branch stations; J. K. Plummer, soil chemist; L. R. Detjen, assistant horticulturist; J. E. Eckert, assistant entomologist; O. J. McConnell, assistant in cotton grading and marketing.

Appointments.—B. F. Brown, chief division of markets; J. H. Henley, specialist in credit unions; W. W. Magill, assistant in marketing fruits and vegetables; R. W. Green, agricultural editor; and F. E. Miller, assistant director branch stations.

The following paragraphs, under divisional headings, give brief summaries of the progress of experimental work during the year, further details being included in the reports of the chiefs of divisions.

AGRONOMY

The soil survey work, which is regarded as a necessary foundation for agronomic studies, was completed in Tyrrell, Durham, Buncombe, and Guilford counties, and some work done in Onslow.

Soil fertility studies have been continued and the use of commercial fertilizers, lime, and crop rotations, including legumes, have been studied

and results given to farmers of the State. It is of paramount importance that soils be built up and kept in a productive state and this idea has been constantly in mind in the experiments carried on by the Division of Agronomy.

At the Washington farm fertilizer experiments on peat soil were continued, and results of three year's tests indicate that more than one ton of lime to the acre is needed and that marl is not quite as efficient a carrier of calcium as are other forms of lime.

In fertilizer experiments at Pender farm using corn, oats, vetch, and cotton in a three-year rotation; with a cover crop on the land, results since 1915 have indicated that nitrogen is the constituent most needed for better crop yields. Phosphoric acid with nitrogen has given more increases than potash with nitrogen.

Results of tests made at Edgecombe farm show as a whole that farmers of the coastal plain section are not using enough fertilizer for cotton and that the formulas used are not the best for the most economical production. More nitrogen and potash should be used with the phosphoric acid remaining about the same, or slightly reduced.

Tests at Iredell continue to show that with the types of soils at this farm, phosphoric acid and nitrogen are the controlling factors for better crop yields. Lime and legumes seem to increase the efficiency of the fertilizer in producing larger crop yields.

The experiments at Central Test Farm having brought out the importance of having more vegetable matter incorporated in the soil so that crops will be better enabled to take advantage of the applications of fertilizer.

In the rotation experiment on the Buncombe farm good results were obtained where lime was used with red clover. The legume plots show much better than where no cover crop was used.

Tobacco experiments at Reidsville gave striking evidence of the effect of seasonal conditions on the action of fertilizers. Muriate of potash afforded more protection against "wild fire" than did sulphate of potash, and the muriate also gave considerable immunity from "sand-drown" and produced a larger growth than the sulphate.

Cotton variety studies were continued during the year and the strains of cotton isolated in 1913, and self-fertilized since that time, have shown no loss of vigor due to inbreeding. During the last six years strain No. 29 has averaged 2,061.78 pounds of lint to the acre, while No. 22, an inferior strain, has averaged only 985.1 pounds of lint to the acre.

Branch stations are being stocked with good strains of field crops to serve as a source for good seed for their sections. At the present time cotton, corn, wheat, oats, rye, soybeans, and vetch are included in this crop improvement work.

CHEMISTRY

Experiments with the object of the elimination of gossypol and D-gossypol from cotton seed and meal were continued, using air, oxygen,

and carbon dioxide. By varying the temperature, the amount of water present, and the time of action, it was found that a part of the gossypol and D-gossypol in kernels could be changed to other forms by the more severe treatments, but that it was difficult to reduce the amount of these two substances to the average gossypol and D-gossypol content of cotton seed meal.

Tests with chemicals were also made which tended to show that the D-gossypol in cotton seed meal is changed by some agency other than oxidation.

ANIMAL INDUSTRY

Investigational work with poultry has progressed very satisfactorily during the year, and for the first time a complete anatomy of the domestic fowl, with illustrations, has been prepared by the division. The mineral content of twenty southern poultry feeds has been worked out, having from one to thirteen analyses of each feed, and the acid-base balance or potential alkalinity and potential acidity worked out for these feeds.

The work with swine has shown that it costs \$4.67 to raise a pig until it is weaned at the age of ten weeks. Home-made mineral mixture for wormy and unthrifty pigs has proven beneficial, and so far salt is not found to be poisonous to pigs. Permanent pasture experiments have shown that each acre of Bermuda saves \$9.03 worth of grain, while Bur Clover pastures save about half the grain. In fattenings hogs with soybeans and peanuts it has been found that there is little difference in the amount of pork per acre, but hogs eat peanuts much quicker than soybeans, and in curing, the meat does not shrink any more when the hogs are fed on soybeans and peanuts and finished on corn than when fed on corn and tankage and shorts. Brine is most satisfactory for curing.

In the dairy experiment work eleven mature cows show an increase of 31,741.6 pounds of milk a year when fed a full ration composed of the same feed they received the year previous, at which time they were given a limited ration. The first crop of heifers shows an increased milk production of approximately 1,500 pounds a year over that of the dams as mature cows. It has been found that ready mixed feeds produce slightly less milk than our home-mixed, and costs \$22 more a ton.

Experiments in sheep feeding have shown that sheep can eat approximately one pound of cotton seed meal per hundred pounds live weight without producing deleterious effects. Sheep can be grown profitably in Western North Carolina, the main obstacles being poisonous weeds.

ENTOMOLOGY

During the year additional data on old projects has been accumulated and several new projects undertaken.

The work with spraying late potatoes has shown highly profitable returns from spraying by a regular schedule of applications, using the home-made Bordeaux Mixture.

Provisions have been made for insect survey work on a larger scale than heretofore, and this has gone forward with increased speed. Four hundred and ninety-three species of insects have been added during 1920 to the list of insects known to inhabit the State, making a total list of 5,747.

Outbreaks of Fall Army-Worm occurred during the summer and a dust poison of one pound of dry lead arsenate to six pounds of dust lime was found successful in controlling these outbreaks. By surrounding a field with a protective furrow and using the dust on the waste grass around the edges inside the furrows, protection is found to be virtually complete.

The tobacco flea beetle project has been continued, the different methods used for control are burning, dipping, dusting, and cutting. Investigational work with June beetle, corn root worm, and leaf hopper has also been continued during the year with satisfactory results.

HORTICULTURE

The work this year has been continued along the same lines as covered in previous reports. The place of origin, history, and description of a number of varieties of fruit of North Carolina origin have been secured, and descriptions secured previous to this season were verified.

Investigational work with peaches has been continued, special attention being given to dehorning, breeding, and the testing of fifty varieties. During the spring of 1920 phenological notes on the different varieties were taken at the Truck Station, which will be of immense value in handling breeding project.

Gratifying results are being secured by variety tests of twenty-two pecan trees, certain varieties showing marked adaptability to North Carolina conditions while others are proving to be undesirable. The value of correct cultural practices is shown by the increased size of trees and size and number of nuts produced. Top-working pecan trees has been continued, and it has been found that top-working should be confined to trees not over eight to ten years old to be entirely successful. As the result of cracking tests conducted during the year, certain varieties that were satisfactory from a productive standpoint proved to be totally unsuited to North Carolina conditions.

The results of the investigational work with strawberries, Irish potatoes, and apples were, in the main, confirmatory of the work of previous seasons.

Through research investigations in connection with Muscadine grapes, a considerable amount of data has been accumulated.

PLANT PATHOLOGY AND BACTERIOLOGY

In the studies of tobacco diseases it has been found that tobacco wild-fire is seed-borne through use of seed from infected pods, that covers from old plant beds may be contaminated, and that the organism may overwinter in the soil.

Experimental work with vetch diseases has shown that fungus is initiated in new fields by planting infected seed. The studies on this disease have been completed and are in press.

Certain selected strains of wheat have been found to be resistant in the Middle West to both stem rust and leaf rust, and the agronomic value of these varieties is being studied in coöperation with the Division of Agronomy. The first year's results show that they possess very striking resistance but are inferior in yield to varieties known to be adapted to this section.

Investigational work on a few definite plant diseases of cotton, cowpeas, lima beans, figs, pepper, soybeans, and tomatoes has been conducted and records made of the diseases studied.

MARKETS AND RURAL ORGANIZATION

Investigations and observations show that there is need for a more remunerative plan of marketing eggs and poultry, especially in the Piedmont and Western sections of the State, where these products are sold locally either at stores, to dealers, or to produce wagons, and when sold in this way farmers do not get what they should for their products. In the eastern part of the State fairly good prices have been obtained by shipping to Norfolk, but for a higher quality product better prices could be obtained farther North.

In order to assist in the sale of cattle a fairly complete list of the feeder and stocker cattle for sale in the western part of the State has been prepared and distributed, and a number of carloads were placed in this way. A cattlemens' association has been formed and a coöperative sale of cattle was held at Spruce Pine in September, where 700 head of cattle were sold. Coöperative shipments of cattle have been limited as in many instances the prices obtained in the State have been from $\frac{1}{2}$ to $1\frac{1}{2}$ cents a pound above northern markets, freight and "drift" considered. However, coöperative shipments of hogs have been carried on in eleven counties, and in this way local prices were advanced from 1 to 3 cents a pound.

Better prices for lambs have been obtained through coöperative marketing, but the wool market was so demoralized that growers shipped their wool to Elkin where it was made into blankets and satisfactory prices were obtained for these.

Owing to a shortage in the seed supply of cowpeas and soybeans, growers who did not sell hastily received an increase in price of more than two dollars a bushel. Advertising in the *Farmers' Market Bulletin* was permitted to growers, provided they guaranteed the purity of variety and germination.

Many growers shipped their surplus stock of sweet potatoes outside the State, and it was found that it is not safe to ship bank-stored sweets any great distance. They rot very badly even in short hauls if the cars

are not well ventilated. Studies of storage houses have indicated that good marketable stock will keep in excellent condition, provided the principles under which the storages operate are not overlooked. Southern farmers have a good opportunity on northern markets if they ship a good quality article at all times.

Considerable improvement has been made in the grading and packing of fruits as the result of inspection work, and already the grades as recommended by the United States Department of Agriculture have been adopted as the legal standard for North Carolina strawberries, potatoes, sweet potatoes, and apples.

DRAINAGE

Records at the gaging station for the determination of the run-off on Third Creek Canal, Iredell County, are complete to date, and it has been found that the average annual run-off on Third Creek is approximately 43 per cent of the average annual rainfall. To obtain an approximate true rainfall it is necessary to average the rainfalls of several stations scattered over the watershed.

The experiments on two tile drainage systems at the Cotton Valley Farm, located in Edgecombe County, have been completed. The soils are known as second terrace deposits and are common to the second bottom lands along many of the rivers in Eastern North Carolina. In an area of 200 acres 12 different soil types were identified, but the texture of the soil is even more variable.

Experiments on the J. T. Lewis Farm in Pitt County have shown that this sandy loam soil is of an open nature and responds almost immediately to tile drainage if an outlet for the water is provided. Most of the drains on this tract have a grade of 0.30 per cent or more and all are apparently in good working order.

Approximately 100 acres of muck soil at Black Land Station in Washington County have been underdrained, and 69 wells for determining the action of the underdrains in lowering the ground water level were installed. It is yet too early to draw any definite conclusions from the experiments, except to state that it is apparently impossible to over-drain these muck soils.

Various special investigations and studies have been made during the year in addition to these.

PUBLICATIONS

Two Technical Bulletins have been published during the year, No. 17, "The Limits in Hybridization of *Vitis Rotundifolia* with Related Species and Genera," and No. 18. "Some F. Hybrids of *Vitis Rotundifolia* with Related Species and Genera," with an edition of 5,000 copies each, of which about 8,000 have been mailed. An annual report of 1,000 copies was issued and distributed.

The Department of Agriculture has issued a monthly bulletin, together with eight supplements, which have been edited and the printing of them superintended from this office. We have mailed about 12,000 of these to the libraries and different specialists and to the small lists which are not routed according to postoffice regulations. Many results of the work at the station have been printed in these bulletins.

All small printing for the station has been handled through this office, and multigraph material has been edited and distributed to the mailing lists maintained by the station. The *Extension Farm News* and special news service have been used in keeping the experimental work of the station before the public.

The reports of the heads of the divisions and the financial statement follow:

FINANCIAL REPORT

The North Carolina Agricultural Experiment Station, in Account
With the United States Appropriation, 1919-1920:

Dr.

	<i>Hatch Fund</i>	<i>Adams Fund</i>
To receipts from the Treasurer of the United States, as per appropriations for the fiscal year ended June 30, 1920, under acts of Congress approved March 2, 1887 (Hatch Fund), and March 16, 1906 (Adams Fund)	\$15,000.00	\$15,000.00

Cr.

Salaries	\$ 9,692.20	\$15,000.00
Labor	1,535.86	
Postage and stationery.....	301.98	
Freight and express.....	78.08	
Fertilizers	1,341.88	
Feeding stuffs	2,000.00	
Livestock	50.00	
Total	\$15,000.00	\$15,000.00

The North Carolina Agricultural Experiment Station, in Account
With Farm and Miscellaneous Receipts.

Dr.

Receipts from other sources than the United States for the year ending June 30, 1920.....	\$ 7,793.08
Balance on hand.....	4,074.49
	<hr/>
	\$11,867.57
Overdraft June 30, 1920.....	351.48
Total	\$12,219.05

SUPPLEMENTAL STATEMENT

	Cr.	
Labor		\$ 4,152.74
Publications		340.09
Postage and stationery.....		15.63
Freight and express.....		27.11
Heat, light, water, and power.....		321.14
Chemicals and laboratory supplies.....		518.98
Seeds, plants, and sundry supplies.....		878.77
Fertilizers		3.00
Feeding stuffs		2,275.79
Library		592.34
Tools, machinery, and appliances.....		794.11
Furniture and fixtures		50.35
Scientific apparatus and specimens.....		27.35
Traveling expenses		607.05
Buildings and land		1,614.60
Total		\$ 12,219.05

We, the undersigned, duly appointed auditors of the corporation, do hereby certify that we have examined the books and accounts of the North Carolina Experiment Station for the fiscal year ending June 30, 1920; that we have found the same well kept and classified as above, and that the receipts for the year from the Treasury of the United States are shown to have been \$30,000, and the corresponding disbursements \$30,000, for all of which proper vouchers are on file and have been by us examined and found correct, thus leaving nothing.

And we further certify that the expenditures have been solely for the purposes set forth in the acts of Congress, approved March 2, 1887, and March 16, 1906.

W. H. RAGAN,
H. L. STEVENS,

Auditors.

(SEAL)

Attest: A. F. BOWEN, *Custodian.*

REPORT OF THE DIVISION OF AGRONOMY

To the Director: The work of the Division of Agronomy has pushed forward mainly during the year along the same lines mentioned in the last report. During all the disturbing factors the work has gone forward without much interruption except in the case of analyses of the soils and certain soil investigations carried on by the Soil Chemist of the division. These disturbances have been due to the loss of the Soil Chemist and of his having to devote a certain amount of his time from the soil work to borax studies. Plans have now been developed to obtain the services of a man for this special soil work.

The work in the main has been conducted along the general lines indicated below:

SOIL SURVEY

The soil survey work of the State which is being conducted by the division in coöperation with the Federal Bureau of Soils has been pushed as rapidly as is consistent with the best interests of the work. The survey is fundamental to almost all of our other work, as it lays the foundation for the conducting of agronomic work in the most intelligent and logical manner. During the year, surveys of Tyrrell, Durham, Buncombe, and Guilford have been completed, and considerable work done in Onslow. It is expected to finish Onslow during the winter and at the same time to carry on work in another of the eastern counties.

SOIL FERTILITY STUDIES

Since the greatest problem before the farmers of North Carolina is the maintaining and building up of their soils in a productive state, a large amount of effort of the Division of Agronomy has been given over to the study of the fertilizer needs of our soils for the production of the best paying crop yields. For it is realized that if our farmers are to get the most out of their farming operations and are to transmit to their children productive farms, it is of the highest importance that they not only secure good yields of the different crops for themselves, but they shall, too, put into operation proper methods of maintaining and building up the producing power of their soils.

It is felt that in order for the general farmer to increase the productiveness of his soil it will not only be necessary for him to use commercial fertilizers and lime judiciously, but also that he shall put into practice a system or systems of crop rotations in which suitable legumes find their place at frequent intervals. It should also be kept in mind that not only will it be necessary for him to grow these nitrogen gathering crops in rotation with his main money crops, but that he shall, after they have been grown, so handle them as to add in a practical way to the organic and nitrogen supply of his soil and at the same time to have the exhaustion of the phosphoric acid and potash reserves of his soil to be as small

as practicable. In order to do this, generally speaking, for the average general farmer, it becomes necessary that a considerable acreage shall be grown every year primarily for soil improving purposes. It is not possible, ordinarily, in growing leguminous crops to remove them from the land after they have been grown and have the growth of them benefit materially, if at all, the producing power of the soil. One of the greatest errors in the minds of many of our people has been that they, in many cases, have assumed that it is possible by the growth of a leguminous crop on the land to build up its productiveness by simply growing the crop on it and removing the crop after its growth. This cannot be expected to materially improve the soil, certainly not in a permanent way, as more plant-food is removed from the soil than is added. It is very rarely the case where such crops when removed would even add to the soil a larger amount of nitrogen than was originally in the soil. County agents and others who are interested in promoting better systems of agriculture among our people may devote to good advantage a considerable portion of their time to giving definite and reliable information to our farmers with reference to the proper principles of building up the producing power of their soils, and at the same time secure from them an economical production of crops. Millions of dollars are being spent annually by the farmers of North Carolina for the use of commercial plant food. This expenditure cannot be made in the wisest way unless proper systems of crop rotation on the farms of the State are being practised and the crops after growth are handled in the wisest way. In other words, commercial fertilizers cannot be expected, nor do they give, generally speaking, the best financial returns when used on poor soils that are handled by poor methods of crop rotation and cultivation.

The soil fertility investigations are being conducted at present by the Division of Agronomy mainly on the following experimental farms and fields: Buncombe, Swannanoa; Iredell, Statesville; Central, Raleigh; Edgecombe, Rocky Mount; Washington, Wenona; Pender, Willard; Granville, Oxford.

To study the deficiencies of the different types of soil throughout the States, tests are being conducted on the distinct types of soil located at the points indicated below:

For Mountain Section

Toxaway Silty Loam, Andrews; Porter's Loam, Swannanoa; Toxaway Loam, Swannanoa.

For Piedmont Section

Davidson Clay, Linwood; Cecil Clay Loam, Statesville; Mecklenburg Clay Loam, Concord; Durham Sandy Loam, Oxford; Granville Sandy Loam, Franklinton; Wilkes Sandy Loam, McLeansville.

For Coastal Plain Section

Norfolk Fine Sandy Loam, Rocky Mount; Portsmouth Fine Sandy Loam, Pantego; Muck, Moyock; Norfolk Fine Sandy Loam, Willard.

In connection with the Farm-life Schools of the State experiments are being conducted along the same general lines as the soil type studies, with one exception that one plot receives stable manure. At present, experiments are being conducted at the following schools:

In Piedmont Section

Lowe's Grove Farm Life School, Durham; Parrish Agricultural High School, Bahama.

In Coastal Plain Section

Aulander Farm-life School, Aulander; Red Oak Farm-life School, Rocky Mount; Sand Hill Farm-life School, Carthage; Craven County Farm-life School, Vanceboro.

MISCELLANEOUS SOIL TESTS

Miscellaneous tests were begun at the following places to study different soil fertility problems:

At Edgescombe Farm.—To study the effect on the quantity and grade of peanuts of applications of limestone, gypsum, and sulphur. To decrease the number of factors no plant food was added to the different plats. This experiment has not yet progressed far enough to justify a statement of results and conclusions.

At Lowe's Grove, Central Farm, and Manchester.—Experiments were started this year to compare the relative efficiency of nitrate of soda and sulphate of ammonia as carriers of nitrogen used on cotton as top-dressers at different dates. These experiments will have to be continued for a time before deduction may be safely made from the results.

At Wadesboro, Iredell Farm, Pender Farm, and Buncombe Farm.—Experiments have been started to compare the relative value of raw rock phosphate, soft rock phosphate, basic slag and acid phosphate as carriers of phosphoric acid, using large amounts of nitrogen and potash to reduce the number of limiting factors. So far acid phosphate has generally given greater and better paying yields than have the other carriers of phosphoric acid.

Work has been started on peat soil at Wenona to determine the effect on the growth of crops by turning the soil at different depths.

Tests with cotton and corn to study the efficiency of Phospho-Germ against a complete fertilizer have been conducted during the year at Wadesboro, and at the Central and Iredell farms. Available results so far do not indicate that Phospho-Germ has measured up in value to the commercial fertilizers used comparatively.

FERTILIZER EXPERIMENTS AND RESULTS AT THE DIFFERENT FARMS

At Washington Farm.—In an experiment on Field A it was planned to study the effect of different combinations of fertilizers on peat soil, with and without lime, when used singly, in combinations of two, and all three elements of plant food. One plot also received basic slag. Although there have been some crop failures in this experiment, sufficient data has been secured, it is felt, to justify a statement that lime is decidedly the first most important constituent needed by this soil, after drainage, for good crop results. The addition of phosphoric acid and potash has shown no benefit when used alone or in combinations and sometimes a depressing effect. Of the crops tried, corn has been the only successful crop grown thus far.

Increasing the amount of lime, within the limits used, has given increases of crop yields. To be enabled to answer the questions of how much and what forms of lime to use on this kind of soil to best advantage an experiment was begun in the spring of 1917. Three forms of lime are being tested—hydrated lime, ground limestone, and marl. The quantities used are the equivalent of one ton, two tons, three tons, and four tons of calcium carbonate per acre applied once every three years. Results of three years' field experiments have been secured and indicate that more than one ton of lime is needed per acre, also that marl is not quite as efficient a carrier of calcium as are other forms of lime.

At Pender Farm.—In 1915 an experiment was begun on Fields A and E at this farm to determine the best combinations of fertilizers to use on this type of soil, using corn, oats, and vetch, and cotton in a three-year rotation with a cover crop always on the land. Several failures have been marked up against this field on account of the corn-bill bug. So far, nitrogen has shown to be the constituent most needed for better crop yields. When two and three times normal amounts of nitrogen are used, increases in crop yields are secured. Phosphoric acid with nitrogen has given more increases than potash with nitrogen. Lime has shown up well, especially with soybeans, and is paying for itself. The field at this farm is in poor physical condition, but it seems from now on more striking results should be secured. The use of basic slag has not shown up quite as well as acid phosphate.

In 1918 another experiment was begun to test the relative efficiency of different carriers of phosphate. The field is divided into eight plots, with limed and unlimed ends. The first crop—corn—was a partial failure, but acid phosphate gave greater yields.

At Edgecombe Farm.—The main fertilizer tests at this farm are on Fields A, B, and C, using a three-year rotation consisting of corn, cotton, and peanuts, with a cover crop every year. In these tests on this type of soil, nitrogen and potash have shown to be the first important constituents of plant food to be supplied for best crops. On Field A the application of nitrogen and potash has paid better on an average than has

the use of a complete fertilizer. With larger amounts of nitrogen and potash, phosphoric acid begins to show up. The results show as a whole that farmers of the Coastal Plain section are not using enough fertilizer for cotton and that the formulas used are not the best for the most economical production. More nitrogen and potash should be used with the phosphoric acid remaining about the same or slightly reduced.

In the rotation tests on this farm the results show that corn every year and cotton every year is better than a simple rotation of corn and cotton without cover crops, when fertilizer is used. When legumes are introduced in the rotation better yields of all crops are secured. The manure plot has shown us that organic matter is a big factor on this type of soil.

The use of rock phosphate has not given as good results in the main fertilizer tests as had acid phosphate.

In the study of different carriers of nitrogen, nitrate of soda still leads, with sulphate of ammonia coming second in value as a carrier of nitrogen. All the carriers of organic nitrogen tried did not show the efficiency in promoting yields that the inorganic forms did.

In the test in sowing *Lespedeza* in the spring the results show that even with the addition of limestone and phosphate our climatic conditions are such that it cannot be safely depended upon as a hay crop. A test to determine the effect of winter-killing on crimson clover, using seed from foreign and native sources, did not show any decided difference last year. It was repeated this year with the same general results.

At Iredell Farm.—With the type of soils at this farm, the evidence is still conclusive that phosphoric acid and nitrogen are the controlling factors for better crop yields. Lime is giving good results and the yields of crops indicate where more organic materials are incorporated into the soil, which can be secured by the use of legumes and lime, the capacity of the soil to make larger crop yields is increased by the increased efficiency of the fertilizer added.

In rotation tests the results show that corn every year and wheat every year with fertilizers is just as good as a two-year rotation of corn and wheat with fertilizers and that when legumes are added in the rotation, such as red clover, cowpeas, or soybeans, better crops are secured.

In the study of different forms of nitrogen carriers, nitrate of soda and sulphate of ammonia have given greater efficiency than any other common carriers of this constituent since the beginning of the experiment. No noticeable residual effect is manifested on plots receiving organic carriers of nitrogen over the inorganic carriers.

In the regular fertilizer experiments, finely ground rock phosphate has not generally shown as efficient as a provider of phosphoric acid as acid phosphate. In the test where rock phosphate is used in amounts varying from 500 pounds to 4,000 pounds complete fertilizer using acid phosphate as the source of phosphoric acid has shown up better in all cases with corn and wheat, except where 4,000 pounds of rock phosphate was used to the acre. This latter plot seemed naturally a little more

fertile from the beginning and has kept up. Beginning in the fall of 1919, Plot No. 1, which received a complete fertilizer, the application was changed to acid phosphate alone. By this change a fairer comparison will be obtained against the different amounts of rock phosphate.

No conclusions can yet be drawn in regard to the efficiency of nitrolene as a carrier of nitrogen.

In the spring of 1919 a test was started to show the efficiency of soft phosphate rock as against acid phosphate. Up to this time acid phosphate has given greater yields with both cotton and corn.

At Buncombe Farm.—In the regular fertilizer experiment, phosphoric acid, nitrogen, and lime seem to be the controlling factors for better crop yields with both bottom and upland soils.

In the rock phosphate test, in which comparison is made of the value of ground phosphate rock and acid phosphate, alone, with stable manure, and with legumes, the acid phosphate has given greater crop yields and net returns under all conditions and with all crops.

Lime is beginning to show up on soils of this farm, and with red clover in the rotation should be considered one of the first materials required to be applied for best paying results.

At Central Test Farm.—The experiments here have brought out the importance of having more vegetable matter incorporated in the soil so that the crops will be better enabled to take advantage of the applications of plant food applied. Nitrogen and phosphoric acid give increased yields, with potash of little importance for increased production until nitrogen has been applied in goodly amounts. It has been shown that a rotation of corn and cotton without lime and using rye and crimson clover as a winter cover crop will not frequently do for this type of soil in this part of the State where dry spells are apt to occur to decrease or stop the crop growth. Basic slag, nitrogen and potash under cotton every year with crimson clover has seemed to have kept up the yields better than any other rotation.

A test was started this year to determine the efficiency of nitrate of soda and sulphate of ammonia on cotton each applied at four different dates. On account of variable season this test will have to be run several years in order to secure most dependable results.

An experiment was started this year to determine the value of Phospho-Germ as a fertilizer. Trona potash under corn is being tested, using different amounts of potash and supplying a liberal amount of both nitrogen and phosphoric acid.

An experiment has been started to see if lime and acid phosphate will be able to produce profitable crops when used with legumes or crop residues turned under every year. Also two forms of lime are used and in different amounts. On Fields A and B at this farm, manure at the rate of seven tons per acre was broadcast this spring and soybeans fertilized and sown to be turned under, and then rye was sown. This was done to bring back these plots to a higher state of fertility, as recent

yields indicated that on account of the poor physical condition the crops were not getting the benefit of the fertilizers applied.

A spring sowing of Lespedeza was started in 1917 in coöperation with the U. S. Department of Agriculture at this and at the Edgecombe farm, using lime and acid phosphate, to see if a successful hay crop could be made. So far negative results only have been recorded. The main reason for the poor results has been due to the growth of grass and weeds before the clover gets started. The seasons in this section seem to be too hot and dry for a satisfactory growth of this crop for hay on soils similar to those of this farm.

SOME GENERAL CONCLUSIONS FROM FERTILITY EXPERIMENTS

At Buncombe Farm.—(1) With the main fertilizer experiments the value of phosphoric acid, nitrogen, and lime is still maintained and are the controlling constituents for better crop yields on both the upland and bottom soils of the Mountain section. (2) The rock phosphate test still shows phosphoric acid carried by acid phosphate as better for larger crops than is finely ground raw rock phosphate. (3) In the rotation experiment, where lime is used with red clover, fine returns have been secured. The legume plots show up much better than where no cover crop was used. (4) The soft phosphate experiment has given indications that acid phosphate is better for larger crops than other carriers of phosphoric acid tried.

At Washington Farm.—(1) The use of all fertilizer mixtures tried has failed to pay. (2) Applications of lime usually assure good crop yields, and the use of two tons is better than one ton. (3) Three tons of calcium carbonate per acre does not increase the yield but very little more than two tons. (4) Marl has been found to be a poorer carrier of lime than is limestone or burnt lime. (5) Three tons of marl are better than two tons. (6) Burnt lime is no better than the use of raw ground limestone.

At Pender Farm.—(1) Nitrogen stands out as first in importance to be provided on this soil. Phosphoric acid comes next when used with nitrogen. The use of potash has not shown up to very good advantage. (2) Lime is quite beneficial on soybeans and probably other legumes.

At Edgecombe Farm.—(1) More fertilizer of the right kind is needed for cotton than is commonly used. The ordinary formulas as used by farmers should have more nitrogen and potash. The use of lime shows up to advantage. (2) A corn and cotton rotation simply is no better than corn and cotton each year on the same land. When legumes are introduced they show up to good advantage. (3) Nitrate of soda and sulphate of ammonia are two of the best carriers of nitrogen for corn and cotton. They will have to be used with proper safeguards.

At Iredell Farm.—(1) Phosphoric acid and nitrogen are still the most important factors for better crops. (2) In rotation studies, corn and

wheat every year is as good as corn and wheat in rotation. Legumes show up in this rotation to good effect. (3) Very large applications (4,000 pounds per acre in each rotation as clover is being turned in) of finely ground rock phosphate have shown up a little better than a complete fertilizer with red clover in the rotation. (4) Nitrate of soda and sulphate of ammonia, properly used, are two of the most efficient carriers of nitrogen tried for the growth of corn and cotton.

At Central Farm.—(1) Organic matter from some source, and if grown lime to assist, stand out as very essential for larger and better paying crop yields. (2) Spring is not the time to sow Lespedeza for hay in this section. (3) The use of basic slag and crimson clover are suitable to keep up the yields of cotton. (4) Phospho-Germ has given poor results in the growth of rye.

TOBACCO EXPERIMENTS AT REIDSVILLE

The general fertilizer experiments have been continued. The most important observation this year was the striking evidence of the effect of seasonal conditions on the action of fertilizers—the resulting growth being much larger than in former years, the quality remaining very good on even the heavier fertilized plots.

The special potash experiments gave results the most striking ever obtained at this farm. “Wild-fire” affected this set of plots severely and the superiority of muriate of potash over the sulphate of potash was really astonishing in affording protection from this disease. The muriate also gave a considerable immunity from “sand-drown” and produced a larger and better growth than the sulphate.

The special nutrition experiments were continued but with the addition of a new set of fields, Nos. 1 and 2, one on old land and the other on similar natured land but freshly cleared from the original forest. Samples of soil were taken from both fields for the purpose of obtaining the humus content. This experiment will be repeated at intervals in future years in order to learn the changes that take place according to treatment with crops and fertilizers.

This year the most striking observation was the relative superiority of corn on the old land and contrasting superiority of tobacco in both yield and quality on fresh land.

The need for phosphoric acid was even more strongly manifested on the fresh land, the growth where this constituent was lacking being almost nothing on the fresh land especially with the corn plots.

TOBACCO EXPERIMENTS AT GRANVILLE FARM

General Fertilizer Tests.—There are thirty-six regular fertilizer plots in this experiment. The object is to determine the best sources of nitrogen, phosphoric acid, and potash, and also the best combinations of these various sources. In 1920 ground limestone, used at the rate of two tons

per acre, was applied on one-half of each of these plots, thereby making a total of seventy-two plots. The indications are that the use of lime has added somewhat to the yields.

Special Potash Plots.—There were twenty plots used in this experiment for determining both the best source and quantity of potash per acre. The potash was applied in different amounts, ranging from nothing to 80 pounds per acre, with and without lime. The indications are that the use of around 40 pounds of potash per acre seems to be about right. While the muriate gave a larger yield than sulphate of potash we are not sure as yet that we recommend muriate in preference to sulphate on account of quality of the tobacco produced.

Variety Tests.—Twenty-one so-called varieties were tested this year, among them being several hybrids which have shown some promise. There were also tested out the new variety known as "Big Gem," "Make All," "Harrison's Pride," and perhaps known in different localities under two or three other names. It was found that this variety was more resistant to "leaf spot" disease than a number of the other varieties. It was found to make a splendid growth, but did not have the body and general character possessed by the Orinocos, Adcock, Gooch, or Warne. It does, however, show promise.

Rotations for Tobacco.—Several rotations have been followed. Conditions will always be a big factor in determining the proper rotation to adopt, but wherever it is possible a grass sod well prepared is an ideal crop to precede tobacco.

Tobacco After Cowpeas.—We have been planting tobacco after cowpeas in rotation with oats for nine years and have used no nitrogenous fertilizers under the tobacco. When topped low and the tobacco is cut it has been found difficult to get color and quality, but since we have been priming and planting twenty-four inches in the drill, splendid color with an average yield of about 1,100 pounds has been secured. While this is not always a safe rotation, it, when used intelligently, may give good results, especially if wire-worms are not present.

Closer Planting Combined with More Intensive Fertilizing.—Twelve plots, ranging from 3,920, 4,704, 5,880, and 7,840 plants per acre were used. This covers spacing, with 4-foot rows, of 18 inches, 24 inches, 30 inches, and 36 inches apart in the row. Each distance of planting was fertilized with 450 pounds, 750 pounds, 1,000 pounds respectively of 5-8-5 fertilizer per acre. The results thus far secured are fairly conclusive in showing that an increased yield with good quality may be obtained by planting closer, say an average of about twenty-four inches in the row with four-foot rows, provided liberal applications of fertilizer are used.

Permanent Tobacco Seed-Bed.—It has been found possible to maintain a permanent seed-bed located at some convenient place near the house, provided steam is used each year to sterilize it. Where a farmer

has a small portable boiler it is easy to make a pan and use this boiler for such purposes.

Nutrition Experiments.—In this experiment there are ninety plots, thirty of which are grown in tobacco, thirty in cotton, and thirty in corn, with different fertilizer treatments. After the cotton, corn and tobacco are harvested these plots are seeded in wheat, oats, and rye, which gives a crop of wheat after tobacco, after cotton, and after corn, and the same with rye and oats. By this means it is possible to get the crop-effects of the three main crops for this section.

Relative Value of Legumes.—There are one hundred and thirty-three plots in this series of experiments. The object is to determine the relative value of the most common legumes in tobacco growing. This is done by planting a certain number of these plots each year in these legumes, after which they are planted to tobacco, cotton and corn with similar fertilizer treatment for each crop. When these cultivated crops are harvested, wheat, oats, and rye are sown. We then get the crop-effects and the legume-effects on each of the succeeding crops. This is an extremely interesting and valuable experiment, but it will require several years to secure data that will be dependable.

RESULTS WITH NITRATE OF SODA ON COTTON WITH PIEDMONT SOILS

In carefully conducted field experiments by the division, nitrate of soda has proven to be one of the best paying of fertilizers, in the production of cotton on "red lands" in the Piedmont section of the State. It is usually one of the cheapest forms of nitrogen on the market, it is readily available, and when properly used on clay and clay loam soils its nitrogen will not leach out much more rapidly than that in other commercial forms of nitrogen. In a seven-years test at the Iredell farm, on red clay soil, a fertilizer having its nitrogen in the form of dried blood was applied to cotton at planting. On an adjoining plat a fertilizer of the same composition was used, except that the nitrogen came from nitrate of soda. Each of these plats received fifty pounds of nitrate of soda per acre as a side dressing. The plat having dried blood at planting, followed by a side dressing of nitrate, made an average yield during seven years of 767 pounds of seed cotton per acre. The plat that got nitrate of soda both at planting and later made an average of 919 pounds of seed cotton per acre. The difference in favor of nitrate of soda being 152 pounds of seed cotton, which at 8 cents per pound (above the present price) is worth \$12.16. When we take into consideration the fact that the fertilizer containing nitrate of soda costs less than that containing dried blood, the difference is still greater. The difference in yield between the two treatments varied from year to year. One year the nitrate of soda treatment yielded 330 pounds above the other. The method of applying dried blood at planting and nitrate of soda later, gave a higher yield than by using nitrate of soda both times only one

year out of the seven, and then the difference was only twenty pounds. In many parts of the Piedmont section the growing season is short and in order to mature cotton properly it is necessary to grow an early variety, to plant early, and to keep the crop growing rapidly from planting until maturity. Nitrate of soda is available to the young plants as soon as it dissolves in the soil water, hence it helps them to get a quick start and so to beat the season. The stiff clay subsoils of the Piedmont hold the nitrate, so that, while available, it does not leach out during the growing season as it might do with a coarse sandy subsoil.

PROFITABLENESS OF USE OF FERTILIZERS ON WHEAT ON MOUNTAIN SOILS

For a number of years fertilizer tests have been conducted by the Division of Agronomy at the Buncombe farm. As a result of these tests it has been found that the proper use of well balanced fertilizer mixtures will pay well for the fertilizer applied. In fact, without the use of a good mixture the growth of wheat is a doubtful crop, under normal conditions, from the standpoint of net returns per acre above the cost of production. What the amount per acre and proportions of plant food constituents should be for this crop is indicated by the resumé given below of our results on fairly typical bottom-land and up-land soils of the mountain section of the State.

On Toxaway Loam (Bottom) Soil.—(1) With only two constituents used, phosphoric acid combined with potash afforded the largest net returns per acre; while nitrogen combined with potash failed to return enough to pay for the fertilizer application. The use of nitrogen and phosphoric acid averaged \$4.56 more profit per acre than did the use of nitrogen and potash, but it was not so great in the former case by \$8.26 as that secured on an average by the use of phosphoric acid and potash combined. With the use of a combination of nitrogen, phosphoric acid and potash, a net return per acre above the cost of fertilizer of \$12.35 was secured. This is forty-seven cents less than what was obtained where a mixture of phosphoric acid and potash was used. Taking all results of the experiments from the different combinations the evidence is quite conclusive that phosphoric acid is the dominant or controlling constituent of plant food for increasing the yield and profit in growing wheat on this type of soil.

(2) When lime is used alone it has been found to give a small increase in yield and a profit after paying for itself. In combination with a complete fertilizer it has shown an annual increase in profit of \$18.23 per acre above the net returns secured by the use of a complete fertilizer alone.

Under the conditions of the experiment the results show that for wheat grown on this type of soil lime may be used at a small profit alone and with a much greater profit when applied in conjunction with a complete fertilizer.

(3) The amount of nitrogen used in the normal fertilizer (400 pounds per acre) applied in the experiments was three per cent, or 12 pounds to the acre. This amount was varied so as to give 6, 12, and 24 pounds of nitrogen per acre. The yields of wheat and straw were very slightly increased as the applications of nitrogen were made larger, but in no case did the gains amount to enough to pay for the increased cost of the fertilizer above the normal amount of nitrogen. In fact with the use of even 6 pounds of nitrogen not enough gain in yields was made to give as great a net profit as when phosphoric acid and potash were used without nitrogen. Until other crop-producing factors are controlled the use of nitrogen for wheat on this type of soil does not pay.

(4) The amount of phosphoric acid in the normal fertilizer (400 pounds per acre) was 7 per cent, which is equivalent to 28 pounds per acre. This quantity was varied so as to apply 14, 28, and 56 pounds of phosphoric acid per acre with normal amounts of nitrogen and potash.

The yields of grain and straw were increased considerably as the amount of phosphoric acid was increased. The net returns secured per acre were \$4.94 when 14 pounds of phosphoric acid were used; \$12.45 by the use of 28 pounds; and with the use of 56 pounds a net return was made of \$25.93 above cost of fertilizer applied. From the increase in yield and net returns made, the use of 56 pounds of phosphoric acid was found the most profitable amount to use. It is indicated by the results from the use of 14 pounds to 56 pounds of phosphoric acid that even heavier applications of phosphoric acid would be more profitable.

(5) The amount of potash in the normal fertilizer (400 pounds per acre) was 1½ per cent equivalent to 6 pounds per acre. This amount was varied so as to apply 3, 6, and 12 pounds of potash per acre with normal amounts of nitrogen and phosphoric acid. The results indicated that 3 pounds of potash are enough to use for wheat on this type of soil. With the use of larger applications of phosphoric acid more potash could probably be used with profit.

(6) Varying amounts of the normal fertilizer applications from 200, 400, 600, and 800 pounds per acre gave progressively increased yields and profits as the quantity of fertilizer was made larger, the results being quite uniform in this regard. The results of the various applications after deducting the cost of the fertilizer showed the following net profits:

200 pounds of fertilizer per acre	gave a profit of \$ 4.60
400 pounds of fertilizer per acre	gave a profit of 12.35.
600 pounds of fertilizer per acre	gave a profit of 34.46.
800 pounds of fertilizer per acre	gave a profit of 39.67.

Putting this in a slightly different way, the first 200 pounds of fertilizer application of 400 pounds yielded \$3.09 per 100 pounds; 600 pounds yielded \$5.73 profit per 100 pounds, and 800 pounds yielded \$4.96 profit per 100 pounds of fertilizer applied.

(7) From the chemical analyses of the various bottom land studied in the Western part of the State the indications are that these results will apply generally to these soils.

(8) In the production of wheat on bottom-land soils, of the character of this, taking all results here reported as a whole, it is recommended that on well prepared land that at least 600 pounds of fertilizer per acre be used, analyzing about 10 per cent available phosphoric acid and something like 1 to 2 per cent nitrogen. It should be the plan of every farmer to reduce the necessity for the use of nitrogen in the fertilizers used. This can be done by the growth and plowing in of leguminous crops and crop residues grown in rotation with wheat.

Porter's Loam (Upland) Soil.—(1) Nitrogen when used in normal amounts (12 pounds per acre) alone did not produce enough increase to pay for the material.

(2) Using a normal amount (28 pounds) of phosphoric acid alone gave a net profit of \$10.68.

(3) With a normal amount of potash (6 pounds) a net profit of \$5.78 was secured.

(4) With the use of a mixture carrying normal amounts of nitrogen and phosphoric acid, and no potash, after paying for the fertilizer a net profit was obtained of \$7.82.

(5) With normal amounts of nitrogen and potash and no phosphoric acid used in the mixture, the increase in yield was barely sufficient to pay for the fertilizer.

(6) By the use of phosphoric acid and potash, leaving out nitrogen, a net gain was made of \$6.77.

(7) Using all three plant-food constituents combined in a complete fertilizer an increase in yield was secured sufficient to give a net profit of \$9.68. Although the average yield from this plat was larger than from that to which phosphoric acid alone was applied, the increased yield is not enough to compensate for the increase in the cost of fertilizer.

(8) The results show that the use of lime alone has given increased yields and profits, and when used in combination with a complete fertilizer a small net profit has been secured over that when a complete fertilizer alone has been used.

(9) The experiments as a whole show, first, that phosphoric acid is the controlling plant food constituent for increasing yields and profits in growing wheat on this type of soil; second, that unless more phosphoric acid is applied the use of nitrogen and potash will be made at a loss; and third, that lime can be used with profit.

(10) The amount of nitrogen in the normal fertilizer (400 pounds per acre) applied in the wheat experiments was 3 per cent of 12 pounds to the acre. This amount was varied so as to give 6, 12, 24, and 36 pounds of nitrogen to the acre. With the exception of the plat which received the heaviest application (36 pounds) of nitrogen, giving a net

profit of 18 cents more than did the plat receiving the lightest application (6 pounds), the profits decreased as the applications of nitrogen were increased. The results indicate that until other conditions are satisfied it is not profitable to use larger amounts of nitrogen than 6 pounds per acre in the production of wheat on this type of soil.

(11) The amount of phosphoric acid in the normal fertilizer (400 pounds per acre) was 7 per cent of 28 pounds per acre. This quantity was varied so as to apply 14, 28, 56, and 84 pounds respectively of phosphoric acid per acre. The largest and most profitable yields were secured from the use of 56 and 84 pounds per acre with normal amounts of nitrogen and potash. As the use of 84 pounds just barely paid for itself it is probable that until other conditions are satisfied 56 pounds of phosphoric acid is enough for profitable wheat growing on this type of soil.

(12) The amount of potash in the normal fertilizer (400 pounds per acre) used, was $1\frac{1}{2}$ per cent or 6 pounds per acre. Varying this amount so as to apply 3, 6, 12, and 18 pounds per acre, respectively, the results show that for the use of 3, 6, and 18 pounds the net profits are practically the same. For some reason the results secured with the use of 12 pounds are very high. Until other conditions are satisfied it is probable that 3 pounds of potash are enough to use for wheat on this type of soil.

(13) Varying the amounts of normal fertilizer application from 200 pounds to 400, 600, 800, and 1,000 pounds per acre gave increased yields and profits for all the applications except where 800 pounds were used. The most profitable application was at the rate of 1,000 pounds per acre of the normal mixture. After deducting the cost of fertilizer the different quantities per acre showed the following profits:

200 pounds per acre of fertilizer gave a profit of	\$ 3.55.
400 pounds per acre of fertilizer gave a profit of	7.04.
600 pounds per acre of fertilizer gave a profit of	11.11.
800 pounds per acre of fertilizer gave a profit of	10.56.
1,000 pounds per acre of fertilizer gave a profit of	13.50.

Putting this in a slightly different way the first 200 pounds of fertilizer yielded a net profit (after paying for cost of fertilizer) of \$1.78 for each 100 pounds of fertilizer; the application of 400 pounds yielded \$1.76 per 100 pounds; 600 pounds yielded \$1.85 per 100 pounds; 800 pounds yielded \$1.32 per 100 pounds, and 1,000 pounds yielded a profit of \$1.35 per 100 pounds of fertilizer.

(14) From the chemical analyses of the various upland soils in the western part of the State, the indications are that the results herein given will apply very well to most of them.

(15) In the growth of wheat on average unmanured upland soils of the mountains, properly treated, taking all results as a whole, it is recommended that something like 600 pounds per acre of a fertilizer analyzing about 10 to 12 per cent phosphoric acid, and 2 to 3 per cent of nitrogen be applied. When soils of this character are built up, the nitro-

gen in the mixture may be reduced or be entirely eliminated. This condition of the soil should be striven for by the growth and plowing into the soil of leguminous crops and crop residues.

CROP ROTATION

In most of our soil fertility studies, a definite system of crop rotation is being and has been used for many years. Good rotations with legumes have been studied against single and double rotations without legumes. The results have developed many facts of interest and importance to farmers of the State. This work is being continued in most of the experimental work with our main crops on the different soil types of different parts of the State. It is feared that many have not realized even yet the value of a good crop rotation in which suitable legumes are included wherever practical to do so. In this connection it might be mentioned that at the Central farm in eight years where a five-year rotation constituted as follows has been followed:

First year—Soybeans sown broadcast and turned in.

Second year—Cotton, followed by rye.

Third year—Rye plowed in, followed by corn, ears gathered and the stalks turned in.

Fourth year—Soybeans for hay.

Fifth year—Wheat, followed by soybeans.

And where two soybean crops have been grown and turned under the yields of the main money crops have been at least quadrupled. For the average general farmer the only way in which he can increase the organic or humus supply of his soil in the most practical way will be by the plowing in of crops and crop residues.

INVESTIGATIONS IN PLANT BREEDING

Cotton Study Work at Central Farm.—The cotton study work under Adams Project No. 14 has been continued and has consisted of further comparisons of several strains isolated from one variety and their first generation hybrids. The strains of cotton isolated in 1913, and self-fertilized since that time, have shown no loss of vigor due to inbreeding. The strains are very uniform and distinct in character. During the past six years strain No. 29 has averaged 2,061.78 pounds of seed cotton per acre, while No. 22, an inferior strain, has averaged only 985.1 pounds per acre.

Seven of the more distinct pure lines were inter-crossed last season. When the first generation plants were grown this season they proved to be more vigorous and earlier than either of their parents. In each case the first generation hybrids were more productive than either of their parents.

The place-effect studies under Adams Project 15 have continued to consist of a further comparison of cotton plants from Mississippi-and-

North Carolina-grown seed of the same pure strain. The work is conducted in coöperation with the Mississippi Experiment Station. The seed from the two sources have been planted in alternate rows and notes have been taken of the number of blooms at the beginning of the blooming period; the height of plants at blooming time; number of bolls set and open bolls at intervals; and the height of plants at maturity. During three previous seasons the Mississippi-grown seed have given earlier, taller, and more productive plants when grown here than the North Carolina-grown seed. Similar results were gotten from the studies in the two localities—at the Mississippi Agricultural College and at West Raleigh, N. C. This season, the fourth year of the experiment, the seed have been grown again in the two localities, the results having reversed themselves in the North Carolina series. This year in this series, the North Carolina-grown seed have given earlier, slightly taller, and more productive plants.

SEED IMPROVEMENT ON THE BRANCH STATION FARMS

In order to supply growers of the State with productive farm seeds of good quality, all of the branch stations are being stocked with good strains of the different field crops. Among the crops being improved at the present time are cotton, corn, wheat, oats, soybeans, and vetch.

The Mountain Branch Station has been stocked with a good strain of Biggs' corn, and of strain No. 38 of the Haberlandt soybeans. The Biggs' corn has furnished a source of good seed corn to farmers for that section during the past three years. Strain No. 38 of the Haberlandt soybeans were a little too late for the bottom-lands on this farm this season. The growth of the strain will be continued on higher and lighter soils during next season.

The Piedmont Branch Station has been stocked with King No. 29 cotton seed, Pedigreed Weekly's Improved corn, Leap's Prolific No. 32 wheat, pedigreed Virginia No. 11 soybeans, and pedigreed Abruzzi rye. Seed of these crops have been increased sufficiently to plant the entire crop of the farm in pure-bred seed. The surplus seed are being sold to growers of that section of the State at reasonable prices.

The Central Branch Station is now stocked with pure seed of King No. 29 and Mexican Big Boll cotton, Cooke's Prolific corn, Leap's Prolific No. 12 wheat, Mammoth Yellow soybeans No. 101, Haberlandt soybeans No. 38, and Virginia soybeans No. 11. The Mexican Big Boll No. 6 cotton selected on the Central Station farm has ranked first in earliness and quality of staple in all of these tests made during the past season. In three of five tests it has taken first place in yield of seed cotton per acre. When all of the results are in it may make an even better showing. During the past season sufficient pure seed have been produced and saved to plant the entire crop at the Central Station farm during the next season. This strain of Mexican Big Boll will be used to replace the strain of King No. 29 previously grown on this farm. The pedigreed

Leap's Prolific wheat No. 12 was increased sufficiently this season to sell 262 bushels to growers of the State. The seed was sold to thirty-eight growers in twenty-two counties. These growers should furnish enough good seed wheat next year for their different communities. Selection No. 101 from the Mammoth Yellow soybean has averaged 5.2 bushels per acre more than the general crop of Mammoth from which it came. Selected strain No. 11 from Virginia has averaged two bushels per acre more than the original seed, and strain No. 38 of Haberlandt soybean averaged 6.2 bushels per acre more than the general crop seed during the past four years. Seed of these high yielding strains are being established as rapidly as possible in sections of the State where they are best adapted.

The selection work with Mammoth Yellow soybeans to increase the oil content during the year has been continued. The selected strains which have furnished the largest oil content have unfortunately remained low in yield. Strain No. 101 has continued to give the largest yield of seed and of oil per acre, though its oil content has averaged 1.1 per cent lower than that of the unselected Mammoth Yellow beans planted as a check.

At the Coastal Plain Branch Station the cotton and corn improvement work previously mentioned has been continued. Through careful selection, Mexican Big Boll cotton has been reduced to a uniform strain and is gradually becoming a favorite variety in the community. If the farm were supplied with a private gin, better seed could be produced which could be sold from the farm in the future. This strain of Mexican is earlier and more uniform than the original strain. In several cases it has yielded more than Cleveland and furnished a staple of much better quality.

The high yielding strain of Mammoth Yellow soybeans, No. 101, has been planted at the Coastal Plain Station to supply the surrounding community with a better yielding strain of this crop than is now being grown in that section.

At the Tobacco and Black-land Stations, selections have been made to improve the quality and yield of corn grown on them.

PUBLICATIONS

The following bulletins embodying the results of field experiments have been prepared and issued during the year:

1. Relative Value of Acid Phosphate and Rock Phosphate on North Carolina Soils. Issued June, 1920.
2. Fertilizer Experiments with Wheat on Mountain Soils. Issued July, 1920.

In closing I wish to commend individually all of those associated with me in the work with crops and soils for the faithful way in which they have aided in carrying forward the work of the division.

Respectfully submitted,

C. B. WILLIAMS,
Chief, Division of Agronomy.

REPORT OF THE DIVISION OF CHEMISTRY

To the Director:—In the last annual report it was stated that work on the effect of gases on the gossypol content of cotton seed kernels was under way, the object being the practical elimination of gossypol and D-gossypol as such from seeds or meal.

These experiments have been continued with air, oxygen, and carbon dioxide. The temperature, the amount of water present, and the time of action have been varied within fairly wide limits. It was found that a part of the gossypol and D-gossypol in kernels could be changed to other forms by the more severe treatments but that it was difficult to reduce the amounts of these two substances to the average gossypol and D-gossypol content of cotton seed meal. It was noted, however, that, with the more severe treatment the amount of gossypol changed seemed to be independent of the nature of the gas used.

These experiments were repeated on cotton seed meal. Treatment with the gases named under the varying conditions referred to did not materially change the content of gossypol nor D-gossypol in cotton seed meal.

Thinking that oxidation might form a satisfactory method for changing gossypol, we sought to accomplish this end by the aid of some cheap chemical which would not leave a deleterious residue in the meal.

The chemicals used were bleaching powder, sodium, carbonate, ferric chloride, ferrous ammonium citrate and ferrous sulphate. Before treatment the meal contained no gossypol and 0.5 per cent D-gossypol. The meal was treated with aqueous solutions of these chemicals at varying temperatures up to the boiling point of water, both with and without bubbling air through the suspension. The time of the runs varied up to five hours. It was found that (1) aerating had very little effect on the final result; (2) under the most severe conditions all of the substances used changed at least a part of the D-gossypol; (3) the bleaching powder was least effective in changing D-gossypol; (4) the iron salts and soda altered approximately 95 per cent of the D-gossypol present.

From these results and such practical considerations as cost and probable effect on the feeding value of the treated meal, copperas was selected as the best reagent for further work on the problem.

Our efforts were next directed towards finding the minimum amounts of copperas and water required to eliminate the greater part of the D-gossypol as such. The effects of temperature and time of runs were also studied. We found that 50 per cent water and 1 per cent copperas at 100°C for ½ hour changed most of the D-gossypol, but if the experiment was run in an autoclave at 125°C, just as much as D-gossypol was changed in the controls which contained water but no copperas as in the samples containing copperas.

These results have led us back to the conclusion indicated by the work with gases; namely, that the D-gossypol in cotton seed meal is changed by some agency other than oxidation. It is probably hydrolysis.

Our most recent experiments indicate that the greater part of the D-gossypol may be changed by heating cotton seed meal under pressure at a sufficiently high temperature, and in the presence of sufficient water. The optimum conditions have not yet been ascertained. There are indications that 50 per cent added water at 125°C for $\frac{1}{2}$ hour or less water and heating for a longer time or at a higher temperature will yield the best results.

I wish to express my appreciation of the services of Mr. F. W. Sherwood who has been connected with the Division of Chemistry for a little more than a year.

Respectfully submitted,

W. A. WITHERS,
Chemist.

REPORT OF THE ANIMAL INDUSTRY DIVISION

To the Director:—Heretofore I have, in my annual report, usually reviewed in more or less detail the outstanding phases of our livestock work. This year, however, I am merely giving statements of projects. If you desire additional information it will be little trouble for me to place it in your hands as practically all of our work is summarized up to date.

POULTRY EXPERIMENTS AND PATHOLOGY

B. F. KAUPP, *in Charge*

Assisted by JOHN E. IVEY, E. G. WARDIN

1. "Digestive Coefficiency Studies."

(The preliminary work of determining the time required for feed to pass through the intestinal tract of fowls at different ages and under different physical conditions, as for example a hen not laying, one sitting, one laying. Young growing chicks. Some analytical work has been done. This work is still in progress at this time.)

2. "Mineral Nutritional Studies."

(We have the mineral content of 20 southern poultry feeds worked out, having from 1 to 13 analyses of each feed. We have the acid-base balance or potential alkalinity and potential acidity worked out for these 20 southern poultry feeds. We have two tests run on growing chicks from baby chicks to 12 weeks of age to determine mineral requirements for growth at this age. We have definitely determined the mineral content of baby chicks, 1½ pound broilers and of hens. Work is still in progress.)

3. "Breeding Studies in Egg Production."

- (a) With Single Comb White Leghorns.
- (b) With Single Comb Rhode Island Reds.
- (c) With Barred Plymouth Rocks.
- (d) Facts or physical signs which indicate egg production.

(Six generations of breeding high fecundity males on low females. Work still in progress.)

4. "Practical Breeding Studies."

- (a) Animal against vegetable proteins.
- (b) Dry Lot vs. Range.
- (c) Influence of velvet bean on growth and egg production.
Same for cotton seed meal.
- (d) Influence of lights on egg production.
- (e) Influence of straw lofts on egg production.

(a) This work is in its second year. Studies were made of comparative rate of growth. Getting the pullets into early laying. Influence on egg production for first year. Records in office, in annual report, and used in teaching and in articles. (b) In its sixth year at Iredell Test Farm and just starting similar work at Pender Test Farm. (c) Velvet beans and pod influence on fattening birds run at West Raleigh plant, effect of same on chicks run at Iredell Test Farm. Influence of bean alone on fattening birds run at Central Plant, West Raleigh. Chick work at Iredell Test Farm, 1920. (d) Influence of lights on egg pro-

duction run at West Raleigh plant. Now in progress. (e) Influence of straw lofts on temperature and egg production running now at West Raleigh plant.)

5. "Market Experiments."

(a) Fleshing Broilers.

(b) Shipping Shrinkage Experiments With Broilers.

(c) Egg Shipping Experiments.

(Considerable data has been amassed and tabulated and studied. Still in progress.)

6. "Influence of Climatic Conditions on Egg Production."

(Still in progress.)

7. "Studies of the Pathological Laboratory."

(a) Enterio-hepatitis of Turkeys.

(b) Diarrheas of Adults.

(c) Diarrheas of Chicks.

(d) Other Apparent Contagious Diseases.

(e) Parasitic Diseases.

(f) Tumors, Both Malignant and Benign.

(g) Non Contagious Diseases.

(h) Histological studies.

(i) Physiological Studies.

(j) Anatomical Studies.

(Progress made with all these. For the first time in the world's history we have written a complete anatomy of the domestic fowl and illustrated it. W. B. Saunders undertook the publication of it as the financing was a heavy problem. Same of Diseases of Poultry from a Medical Standpoint.)

8. "Experimental Extension Poultry Work."

(We furnished 60 sittings of eggs first year and 20 sittings second year. Good results are being obtained and valuable plans are being worked out.)

SWINE EXPERIMENTAL WORK

EARL HOSTETLER, *in Charge*

1. "Curing Meat."

(Brine is most satisfactory for curing. Meat from hogs fed on soybeans and peanuts and then finished on corn does not shrink any more than hogs fed on corn and tankage or shorts.)

2. "Peanuts—the Kernel—for Fattening Hogs."

(Work been under way one year only.)

3. "Permanent Pasture for Pigs."

(Each acre of Bermuda saved \$9.03 worth of grain.)

4. "Cost of Raising Pigs to Weaning Time."

(It cost \$4.67 to produce an average pig until weaned at ten weeks of age.)

5. "Salt for Pigs."

(So far we have not found salt to be poisonous.)

6. "Mineral Mixture and Medications for Wormy and Unthrifty Pigs."
(A mineral mixture—home made—and the National Hog Remedy were both very beneficial. No particular advantage in using patent preparation.)
7. "Soybeans and Peanuts for Fattening Hogs."
(Where there is normal yield there is little difference in the amount of pork made per acre, but the hogs eat the peanuts much quicker than the soybeans.)
8. "Hardening the Bodies of Hogs After Peanuts."
(Work not been under way long enough for definite conclusions, except to say that the bodies can be hardened so they are completely acceptable.)
9. "Burr Clover Pastures for Pigs."
(Burr Clover pastures save just about one-half the grain.)
10. "Tankage Versus Fish Meal as Protein Supplements for Fattening Hogs."
(Fish meal is less palatable than tankage but gives slightly better and cheaper gains.)

DAIRY EXPERIMENTAL WORK

STANLEY COMBS, *in Charge*

1. "Herd Development Work."
(The first crop of heifers to mature shows an increased milk production of approximately 1,500 pounds per year over that of the dams as mature cows. Not all of these animals have come into milk to date. The indications are that this milk production will be increased by the heifers that are now maturing.)
2. "Peanut Meal vs. Cotton Seed Meal for Maturing Heifer Calves."
(Have not had sufficient time to mature the oldest heifers.)
3. "Feeding For Milk Production."
(Eleven mature cows showed an increase of 31,741.6 pounds of milk per year when fed a full ration composed of the same feed that they had received the year previous, at which time they only received a limited ration.)
4. "Home-mixed vs. Ready-mixed Feeds For the Dairy."
(To date one grain has been fed. This produced slightly less milk than our home-mixed ration and cost \$22 more per ton.)
5. "Cost of Milk Production."
(Published in the N. C. Department of Agriculture Bulletin No. 266, March, 1920, "A Study of the Factors Involved in Producing Milk in North Carolina.")
6. "Cotton Seed Meal Feeding Work—Effect on Cows and Heifers in Reproduction."
(In coöperation with Beef Cattle Office. To date the work has been of a preliminary nature. On January first the lot of 24 animals was divided into five lots, each receiving different rations.)

BEEF CATTLE AND SHEEP

R. S. CURTIS, *in Charge*

Assisted by EARL HOSTETLER, F. F. PEDEN, GEORGE EVANS

1. "Milk Sickness, or Trembles."
(Have shown that milk sickness or trembles is caused by weed commonly known as Rich Weed or White Snake Root.)
2. "Effect of Cotton Seed Meal on Cows and Heifers in Reproduction."
(In coöperation with Dairy Experimental Office. Have determined partial effect of cotton seed meal on health, reproduction, and vision.)
3. "Effect of Cotton Seed Meal on Reproductive Qualities of Sheep."
(Have shown that sheep can eat approximately one pound of cotton seed meal per 100 pounds live weight without producing deleterious effects.)
4. "Methods and Cost of Maintaining Breeding Ewes and Producing Lambs."
(Have determined cost of producing lambs and practicability of using pastures for maintaining sheep.)
5. "Wintering Beef Cattle in Western North Carolina."
(Concluded six years work October 1, 1919. Two official bulletins from Department of Agriculture.)
6. "Winter Fattening of Beef Cattle."
(Have determined relative value of feeding various quantities of cotton seed meal under given conditions.)
7. "Sheep Production in Western North Carolina."
(Have determined that sheep can be grown profitably under Western North Carolina conditions. Main obstacles are poisonous weeds. Temporarily discontinued.)

ANIMAL NUTRITIONAL WORK

J. O. HALVERSON, *in Charge*

1. "A Study of 'Soft Pork.'"
(Dr. Halverson has devoted much time since coming with us, April 1, getting acquainted with our conditions and problems. He now has hold of the "Soft Pork" problem and has outlined definite plans for continued investigation.)
2. "Mineral Supplements, Chiefly Calcium, for Southern Animals."
(This is a continuation, with modifications, of the work already under way.)
3. "Nutritive Value of the Peanut."
(This is a study really supplementary to the "Soft Pork" studies. The peanut is known to be high in protein and oil, but its nutritive value in other necessary growth constituents is not so well known. Halverson is conducting this study with young albino rats to determine the adequacy of (a) the salts present in 30 per cent peanut meal containing the

hulls and in the hulled peanut, (b) the vitamins present, (c) the protein efficiency for maintenance of growth, (d) the value of alfalfa meal in supplementing the raw peanut kernel with fat soluble A and inorganic material.)

4. "The Toxicity of White Snake Root."

(See note under Beef Cattle Office.)

5. "Onion Flavor in Milk."

(Dr. Halverson and Combs are continuing this project.)

PUBLICATIONS DURING THE YEAR

The Value of Soybean Meal as a Food for Chicks, by Kaupp, in *Poultry Item*.
Fattening Birds for Market, by Kaupp, in *Poultry Item*.

Secondary Agricultural Schools as a Means of Furthering Poultry Work, by Kaupp, in *Poultry Item*.

Division of Profits Where Landlord and Tenant Raise Poultry, by Kaupp, in *Poultry Item*.

Dry Lot vs. Range Methods of Handling Hens, by Kaupp, in *Poultry Item*.

Data on Amount of Feed Required to Produce a Dozen Eggs by Hens of Different Breeds, by Kaupp, in *Poultry Item*.

Factors Which Influence Winter Egg Production, by Kaupp, in *Poultry Item*.

Prolapse or Eversion of the Oviduct and Cloaca in a Laying Hen, by Kaupp, in *American Journal of Veterinary Medicine*.

Bacillary Edema and Suppuration of the Fowl, by Kaupp, in *American Journal of Veterinary Medicine*.

Egg and Poultry Markets Before and After the War, by Kaupp, in *Progressive Farmer*.

Poultry Score Card, by Kaupp, Extension Circular No. 35.

A Case of Spindle celled Sarcoma of the Skin and Subcutaneous Tissues, by Kaupp, in *Journal of American Veterinary Medical Association*.

Investigation of the Death of Chicks, Coccidian Hepatitis, by Kaupp, in *Journal of American Veterinary Medical Association*.

A Study of Some Feed Mixtures with Reference to Their Potential Acidity and their Potential Alkalinity, by Kaupp, in the *Journal of the American Association of Instructors and Investigators*.

A Study of the Factors Involved in Producing Meat in North Carolina, by Combs, in *North Carolina Department Bulletin No. 266*.

The Value of a Full Ration for the Dairy Cow, by Combs, in *Extension Circular No. 107*.

Better Males Are Needed for the Farm Flock, by Kaupp, in *Poultry Item*.

A Study of the Factors Involved in Producing Milk in North Carolina, by Combs, in *North Carolina Department of Agriculture Bulletin No. 266*.

Score Cards for Mules, by Hostetler, *Extension Circular No. 109*.

The Value of Mineral Mixtures for Hogs, by Gray and Hostetler, *North Carolina Department of Agriculture, Bulletin No. 268*.

Score Card for Draft Horses, by Hostetler, *Extension Circular No. 100*.

I cannot close the report without commending the good work and excellent spirit of the men and women connected with the Animal Industry Division.

Yours very truly,

DAN T. GRAY,
Chief, Animal Industry Division.

REPORT OF THE DIVISION OF ENTOMOLOGY

To the Director.—The year has witnessed the accumulation of additional data on old projects, publications of results in several, and the taking on of several new projects, outlines of which have been duly filed with you.

INVESTIGATION WORK

Potato Spraying.—The spraying work with late potatoes has been continued at the Mountain Branch Station at Swannanoa, in which work Mr. Leiby and Mr. Haber have had the best coöperation from Mr. Clapp, superintendent of the farm. The results of five years of this work were reported in Department Bulletin 254, and show a highly profitable return from spraying by a regular schedule of applications. Tests for the third year were conducted on early potatoes in the eastern part of the State, and we are finding the results there to be more profitable than we had anticipated.

The whole subject of spraying potatoes is presented in easily understood form in Extension Circular No. 103 by Mr. Leiby, issued March, 1920. Only a lack of labor should stand in the way of every commercial potato grower in the State following a regular spraying program with home-made poisoned Bordeaux Mixture. Although the results are less spectacular because the tubers grow underground, yet the actual profits are fully as striking as in the spraying of apples.

Larger Corn Stalk-borer.—After five years investigation of this insect by Mr. Leiby, the results have been published in Department Bulletin 274 (August, 1920), and I wish to commend this piece of work in the highest terms. The careful working out of the life-history of the insect shows that the farmer who needs to combat it can avoid much of the trouble by planting May 25 or later, so as to escape injury by the first generation, which practice will in itself lessen the number of the second generation. Liberal fertilization helps the corn to outgrow later injury, and rotation of the crop also lessens liability to attack. Finally a close study of the winter mortality of the insects shows that plowing out of the stubble in the fall greatly increases the death-rate among them. All of which is abundantly supported by observations, recorded data and field tests. The problem affects mainly the eastern part of the State.

For years I have referred to this project as under investigation, and it is a pleasure now to point to the published result.

Dusting Late Cabbage to Control Worms.—Tests under this head are still under way at the Mountain Station, and results continue to show a profit from dusting the growing plants frequently and lightly with arsenate of lead and air-slaked lime in proportion of one pound of the poison to eight pounds of lime.

Pecan Insects.—As indicated in previous report this project is well advanced, and should be ready for publication in a year or so.

Insect Survey.—For nineteen years we carried this permanent and comprehensive project without special funds and without anyone especially assigned to it, most of the work during those years being done by the writer (Sherman). During that time we built up a card-catalogue of insects of the State enumerating (December, 1919) 5,254 species. At the meeting of the Board, December, 1919, provision was made whereby we engaged Mr. C. S. Brimley, who has since been engaged on this project. The list has gone forward with increased speed, 493 species being added thus far during 1920, bringing the total to 5,747 species (kinds) of insects now known to inhabit the State.

The growth of the State list is but an index—correlated with it is our constantly growing collection—and from this work we are better enabled to understand the scope of our field and to solve many puzzling problems without depending wholly on specialists elsewhere who are crowded with other work. Many of the additions to the list have been beneficial parasitic insects, identified by Mr. Brimley of our own staff. I wish to re-state the conviction, given from time to time during the past twenty years, that I can conceive of no project more broad and important in its whole bearing than this one—it is economic, scientific, biologic—and it is permanent, we will never exhaust it in the lifetime of any of our present workers.

Fall Army-worm.—During the summer outbreak of this pest we tested the use of dust poison at the rate of one pound dry lead arsenate to six pounds dust lime—this being the same (except a little more concentrated) as the mixture we so successfully used against green clover worm in 1919. It worked well. There is no doubt in our minds that the dry dust poisons simplify the general problem of controlling sudden outbreaks of this and related insects on low-growing plants. When we first surrounded a field with a protective furrow, and then used the dust on the waste grass around edges *inside* the furrow, the protection was virtually complete. The key to success lies in detecting the outbreak, early, and being so prepared as to apply the measures without delay.

Cutworms.—In the first year's study on this project Mr. Brimley has reared to maturity a number of species, and is getting data on the relative abundance of them in the different parts of the State. Thus, while the list of destructive species at Wilmington may be almost identical with a similar list from Asheville, yet the one or two species which are most prevalent in one of these places may not be the ones which are most prevalent in the other.

Household Insects.—Mr. V. R. Haber is following this project, with studies of cockroaches, clothes moths, fleas, and others of that general class. Curiously enough, since we started this project several matters under this head have come to our attention which were of important proportions:—(1) a cotton mill had hundreds of spools of yarn which were cut to pieces in storage by a small worm—and (2) a hosiery mill

sent samples of manufactured hose which were being riddled by insects. Such outbreaks in wholesale quantities of clothing materials are too important to be ignored.

Fall Canker-worm.—An investigation by the writer (Sherman) was made in May and June in an area on Humpback Mountain, Avery County, which was attacked for the fourth consecutive year. As this area, like most of the others involved, consisted of wild forest without roads, no artificial means of control was practicable, and attention was centered upon the natural enemies which tend to subdue the worms. Omitting details, which are on record in our notes, it may be said that insectivorous birds seemed to gradually concentrate in the area, and the same seemed true of certain predaceous insects. Insect parasites of the worms appeared to be scarce, likewise fungous and bacterial diseases, but an egg-parasite prevented the hatching of a considerable percentage of the eggs. In the area studied the defoliation was not as severe as it had been in previous years, and this gives ground for the hope that the natural enemies may gradually gain control there and elsewhere, although some of the areas suffered this year as badly as before.

And thus the problems arise—even when we have a full schedule of specified projects—sudden and unforeseen outbreaks will create issues which must be studied at once, even if scheduled ones have to be held in abeyance for a time. For we have not yet learned to know in advance what insect problems will arise in any given year.

Respectfully submitted,

FRANKLIN SHERMAN,
Chief, Division of Entomology.

Report of Entomologist

To the Director.—I have the honor of transmitting herewith a report covering the work of the Division of Entomology for the past year. The work of this division is divided between the Hatch and Adams Funds under the following projects: Hatch Projects, corn ear worm, tobacco flea beetle, Mediterranean flour moth, and June beetle. Adams Projects, gloomy scale, pea and bean weevils, melon beetles, corn root worm, and leaf hoppers.

The corn ear worm project is carried on in coöperation with the Division of Cereal and Forage Crop Insects, United States Department of Agriculture and is intended to solve certain methods of control and also to determine the percentage of injury to corn caused by this insect. This work has just been inaugurated this year and is not far enough advanced at the present time to yield any special results. The methods of determining the percentage of injury have been developed while prosecuting this project and promise to yield some interesting results, especially when they have been finally tabulated for all of the principal varieties of corn grown in the State. The data that have been gathered

for the past twelve years on time of planting in relation to injury by ear worm are merely incidental to the corn root worm problem, but they show some very interesting results in this connection which may be summarized briefly by stating that as a general proposition corn planted before mid-season for any given locality has a decidedly smaller percentage injured by the ear worm. Other phases of this problem are being followed at Willard, Raleigh, and Swannanoa.

The tobacco flea beetle project is being continued at Oxford and consists principally of trying out methods of control that seem feasible. These methods have been carried out along four main lines, burning, dipping, dusting, and cutting.

In burning an effort is made to locate the chief hibernating places of the beetles and these are thoroughly burned over during the winter. Our studies have shown that the flea beetles hibernate chiefly around the edges of fields in woods, along dead furrows, ditch banks, and similar localities, which give a shelter of dried grass or leaves. It becomes, therefore, a relatively simple matter to burn over the most favorable localities in winter, using the ordinary precautions in regard to forest fires. This method has given excellent results this past year and needs to be further extended for the coming year.

Dipping the plants at transplanting time has the advantage that it enables us to put a good application of poison on the plants at a minimum expense and at a time when the plants need the protection very much indeed. Our experience during the past year would show that caution is needed in the application of this remedy and further trials during the coming season will undoubtedly clear up the questionable points.

During the past year we have carried on rather extensive experiments in dusting, but the results would seem to indicate that at present prices the farmer could not afford to dust his tobacco save in very severe outbreaks of the horn worm or of the flea beetle. These experiments must be continued, however, to see whether it is not possible to simplify them to such an extent that the practice would be profitable to the farmer.

For several years your entomologist has urged the necessity of the tobacco farmer keeping down the suckers in the tobacco fields after the crop is harvested, and never has the importance of this been more apparent than during the past season. If these suckers are allowed to grow up they furnish ideal conditions for all types of tobacco insects, but especially for flea beetles. The destruction of these suckers would drive the flea beetles into hibernation early and this would mean that most of them would die of starvation before the next spring. Some experiments conducted this past year show that from 98 to more than 99 per cent of the beetles forced into hibernation before the middle of September die before tobacco is up in the seed beds the next spring, whereas in a few cases as many as 60 per cent of the beetles which feed on tobacco suckers until frost were able to live through the winter. It

takes but a moment's reflection to see that if the practice of destroying the suckers should become general the loss due to tobacco insects in this State would be very materially reduced.

In this connection it seems worth while to note that two tobacco farmers in the eastern part of the State, who have put into practice the recommendations for the control of tobacco flea beetles on tobacco seed beds as outlined in our Bulletin No. 239 on tobacco flea beetle and its control, that the remedy has proven entirely successful. One farmer who had 25 acres of tobacco reports that the remedy was worth at least \$25 an acre to him; and another farmer who cultivated 60 acres reports that the remedy was worth \$30 an acre to him. These reports are especially encouraging in the light of the fact that it is very difficult to get our tobacco farmers to use any methods of control for tobacco insects. And another phase of the situation which is especially interesting to me is the fact that these farmers read our bulletin and put on the demonstration at their own initiative and carried out all details for themselves, which is sufficient comment it seems to me on the fact that our bulletins do sometimes reach the folks for whom they were written. How many other farmers in the State have done the same thing it is, of course, impossible for us to say.

During the past summer we received notice that one of the largest flour mills in the State was badly infested with the Mediterranean flour moth. A preliminary inspection showed that the mill was in a very bad condition, especially in the old wooden mill. Conditions were only about half as bad in the new brick mill. It was estimated that the mill was losing about \$900 per month from loss of time due to closing down the mill to clean up, for chemicals used in fumigating and in various other ways, yet in spite of this the condition was getting gradually worse. It was decided to fumigate the mill with hydrocyanic acid gas, owing to a variety of conditions which made it impossible to use heat. In the new brick mill, which is of modern construction with tight steel sash, the first fumigation was entirely successful, and not a single moth has been seen since. In the old mill about a dozen moths were seen after the first fumigation, so it was immediately fumigated again. After the second general fumigation only three or four moths were seen, where before they occurred by the thousands. These seemed to be coming from beneath the floor and from the boots of the elevators, places not reached by the general fumigation, so special fumigating jars were devised and these places fumigated. Since that time not a single moth has been seen. Thus at a cost estimated at less than \$500 this mill has been freed from a monthly expense of nearly double that amount, and yet with all this expense they were facing a situation which was gradually growing worse and which threatened to become unmanageable.

For several years I have been noting the work of the green June beetle on various crops. It was, therefore, with a great deal of pleasure that I received and transmitted to you for publication the manuscript of a bulletin dealing with this pest from Mr. J. J. Davis, now the Entomolo-

gist of the Indiana Experiment Station, embodying the results of several years work with this insect. This bulletin will make available for our farmers, fruit growers, and truckers many valuable remedies for the control of this pest, which is one of our troublesome secondary pests. Since this bulletin has been written we have found that this insect is frequently a very troublesome pest to tobacco beds, often practically destroying them. This past spring one of the large beds at the Oxford Branch Station was completely riddled by this pest and inquiry developed the fact that this trouble was more or less general and was usually attributed to earthworms.

The gloomy scale project has been closed and the manuscript of a bulletin covering the more important phases has been prepared for publication at an early date.

The pea and bean weevil project is being continued, the principal attention being given to life history studies of three species and to a study of the effects of drying beans and peas on injury by these weevils.

The corn root worm project is being carried on principally at Willard, Raleigh and Swannanoa. Data on time of planting show many interesting points, but these must be continued for several years before they are conclusive.

Most of my time during the past year, however, has been devoted to the leaf hopper project and in this project we have been following six principal lines of work. A study of certain forms living on tidal flat grasses, and certain forms living on mountain pasture, a revision of the group plant hoppers, a bibliography of the group, and the economics of some of the more important pests of this group.

The ecological relations of the forms living in the great stretches of tidal flats along our coast is proving not only interesting but is yielding results far beyond our expectations. Some of these results have been summarized in papers appearing in scientific journals which are appended as a part of this report. The same is also true of the species living in our mountain pastures, but this work has not been pushed to the same extent because of the distance to suitable observation points. The revision of the plant hoppers is about ready for the press and it is hoped that this will put our knowledge of this group on a better foundation than it has ever been before and make it possible not only for us to pursue our further studies in this group with better results but that it will also be useful to other entomologists.

During the course of these studies we have found it necessary to work out a very careful bibliography of the leaf hoppers of the world. This work had reached a rather advanced stage and being urged by other students it seems desirable to compile this for publication. The size of this task may be better appreciated when it is known that this bibliography will cover some 2,500 titles which have been published in some 150 separate works, the rest being scattered in about 400 separate jour-

nals, many of which have run beyond the score of volumes and which have been published in all of the major European tongues.

More and more we are learning to appreciate the importance of leaf hoppers as destructive farm pests. And all of the work mentioned above is being done as a preliminary to real serious work on the economics of the group. To this end we have been studying a few of the outstanding pests of the group, especially the apple leaf hopper which is destructive to soybeans in the east, potatoes in the west, and apples in all sections; and the clover, alfalfa and grass species.

During the past year the writer has published, or has had accepted for publication, the following papers, which embody the results of work carried on by the Station and separates of these papers as far as available are attached as a part of this report:

Z. P. Metcalf, a Suggestion for a Better Popular Name for the Fulgoridae (Hemip.). *Entomological News*, volume XXXI, pages 57-58.

Z. P. Metcalf, Some Ecological Aspects of the Tidal Zone of the North Carolina Coast. *Ecology*, volume I, pages 193-197.

Z. P. Metcalf, Dipping Tobacco Plants at Transplanting Time for the Control of the Tobacco Flea Beetle (*Epitrix parvula* Fabr.). *Journal of Economic Entomology*, volume XIII, pages 398-400.

Z. P. Metcalf, Labeling Illustrations, Transactions of the American Microscopical Society, volume XXXIX, pages 146-162.

Z. P. Metcalf and Herbert Osborn, Some Observations on Insects of the Between Tide Zone of the North Carolina Coast. *Annals of the Entomological Society of America*, volume XIII, pages 108-117.

Z. P. Metcalf and Herbert Osborn, Life History Notes on *Tibicen viridifasciata* Walker. In press.

Z. P. Metcalf and Herbert Osborn, A List of the Cicadellidae of Swannanoa. In press.

Respectfully submitted,

Z. P. METCALF,
Entomologist.

REPORT OF DIVISION OF HORTICULTURE

To the Director:—I herewith submit the report of the experimental work in the Division of Horticulture for the fiscal year ending June 30, 1920.

The experimental work of the division is being continued along the lines of the projects described in previous reports.

During the year considerable attention has been given to a more thorough direction and organization of the work. The organization of investigation so that direct attention to problems of outstanding importance may be developed has been borne in mind. Every attempt is being made to develop a program of work which will contain live projects definitely adapted to fundamental and special problems of the State. The projects are being organized so that problems of first importance will be selected and so that the expenditure of funds and energy on problems of only local application will be limited. Every project is reviewed each year with a critical attitude to see if it is fulfilling the purpose for which it was intended.

EXPERIMENTAL WORK IN POMOLOGY

1. *Variety Work in Pomology* (C. D. Matthews and J. M. Dyer).

Notes and observations on the behavior of varieties of fruits in the different sections of the State are made from year to year. These notes and observations show the range of adaptability of the varieties in different sections.

Much time and care is expended each year in writing, revising and checking descriptions of almost all of the important varieties of fruit grown in the State. These descriptions are to be used in future publications, and are employed by the division as an aid in identifying varieties of fruit sent to the office from over the State.

2. *Native Fruits of North Carolina* (C. D. Matthews).

The place of origin, the history, and the description of a number of varieties of North Carolina origin have been secured. When opportunity offered the descriptions of varieties secured previous to this season were verified. Paintings and photographs have been made of the most important varieties.

3. *Investigational Work with Peaches* (Mountain Station, Truck Station, Piedmont Station, Coastal Plain Station). (C. D. Matthews and J. M. Dyer.)

(a) "*Dehorning*" *Peach Trees*. During this last season additional progress with the peach "dehorning" project has been made. From the results so far secured it has been shown that in years when the buds are killed by cold, "dehorning" is a profitable practice in renewing old trees. It has been found that the operation may be done relatively late in the spring with satisfactory results.

(b) *Peach Breeding.* It is the object of this project to produce improved commercial varieties that are more suited to North Carolina conditions than are the present varieties. It is the purpose, also, to produce varieties hardier in bud than the present commercial sorts.

To provide working material for this project a variety orchard, containing over 60 different varieties of peaches, was planted at the Truck Station during 1917. These trees have made a very satisfactory growth since being planted. During the last year nearly all the varieties had a partial crop and some very valuable preliminary work was done in regard to collecting data concerning the characteristics of the different varieties. There is a good set of fruit buds on the trees and active work is to be done on this project during the following year.

(c) *Hardiness of Peach Varieties in Western North Carolina.* Twenty varieties of peaches, comprising varieties adapted both to extreme northern and to southern conditions, were planted at the Mountain Station in the spring of 1919 to furnish material for work on determining the relative hardiness of different peach varieties in Western North Carolina. These trees have made a very satisfactory growth since being planted.

(d) *Phenological Studies with Peaches.* The practice of collecting phenological notes on the peach varieties in the varietal peach orchard at the Truck Station was started during the spring of 1920. These notes will be of immense value in handling the breeding project.

(e) *Variety Testing with Peaches.* Full notes were taken on the behavior of over 50 varieties of peaches at the Truck Station. Descriptions of these varieties were secured.

4. *Investigational Work with Pecans.* (Truck Station, Coastal Plain Station and Piedmont Station.) (C. D. Matthews and J. M. Dyer.)

(a) *Variety Testing.* Twenty-two of the most important southern varieties are included in this test which has been conducted for 14 years. Gratifying results are being secured from this work, as certain varieties are showing marked adaptability to North Carolina conditions, while others are proving to be undesirable. At this time, valuable recommendations regarding pecan varieties for planting in this State can be made. According to the results secured the Schley, Stuart, and Alley varieties are the most desirable for Eastern North Carolina.

(b) *Individual Tree Performance Records.* The securing of performance records of the individual pecan trees in the experimental orchards at the several stations is being continued from year to year. Such a record affords a more detailed study of the behavior of the different varieties. As a result of the individual tree performance records it has been noted that trees of the same variety under identical conditions are uniformly heavy yielders, while others are very poor producers, that some produce uniformly large nuts and others uniformly small nuts. As these individual performance records suggest the possibility of improv-

ing and standardizing individual yields by bud selection, work has been started along this line.

(c) *Cultural Practices.* The value of correct cultural practices, such as tillage and the use of cover crops, is clearly shown in the increased size of trees and in the increased size and number of nuts produced when compared to trees and their products grown in sod. To determine the most desirable system of tillage and cover cropping to be employed in pecan orchards, work of this nature is being conducted at the Branch Stations.

(d) *Pecan Breeding.* The seedlings, as a result of pecan breeding work, that were set in 1915 at the Truck Station, are making a satisfactory growth. Some of these seedlings are of bearing size and should produce some nuts during the coming year.

(e) *Top-working Pecan Trees.* The investigations dealing with the methods of budding and grafting employed in top-working pecan trees was continued this year. It has been found that a combination of both grafting and budding should be used to secure the most satisfactory results. As a result of years of investigation it is the opinion of this division that top-working should be confined, as a general rule, to trees not over 8 to 10 years old, to be entirely successful.

(f) *Cracking Tests with Pecan Varieties.* The cracking test of the different varieties is made each year. The cracking test is a necessary adjunct to the performance record of a given variety in determining its value in a certain section. Very often a variety is highly satisfactory from a productive standpoint, but the cracking test shows it to be nearly worthless from an utility viewpoint. The cracking test shows the number of nuts per pound and determines the per cent of unbroken halves the variety will crack out, the per cent of shrunken kernels, the per cent of physiological spot, the per cent of faulty nuts, and shape and size of the kernels, the texture, quality and flavor of meat, the per cent of meat and the thickness of shell. As a result of these cracking tests conducted each year certain varieties that were satisfactory from a productive standpoint proved to be totally unsuited to North Carolina conditions.

5. *Investigational Work with Strawberries.* (Truck Station.) (C. D. Matthews and L. H. Nelson.)

(a) *Variety Testing.* The variety testing project with strawberries was initiated with the purpose of determining whether or not there were any other varieties more desirable as commercial market varieties than Klondike and Missionary, the two leading commercial varieties. For this State the most profitable berry combines the characteristics of productiveness, earliness, and shipping quality. None of the varieties so far tested have shown themselves superior to Klondike and Missionary as commercial varieties. Several of the varieties have shown themselves valuable for home use.

(b) *Cultural Practices*. During the year experiments to determine the most desirable planting dates were conducted, as well as work to determine the value of removing blossoms and cutting runners. This project has not been in operation a sufficient length of time to furnish any conclusive information.

6. *Investigations with Apples*. (C. D. Matthews and J. M. Dyer.)
(Mountain Station.)

(a) *Pruning*. The pruning project was begun during the year with the intention of securing information on the desirable height to head apple trees, to determine the comparative value of the open head and the modified leader system of training, and to secure information on the amount of annual pruning most desirable. To supply material for this work an orchard containing approximately 128 trees, was planted at the Mountain Station in the spring of 1919. The trees have made a very satisfactory growth and the first year's work has been completed as planned.

(b) *Apple Thinning*. (Mountain Station and Piedmont Station.) Experiments to determine the effect of thinning fruits and leaves from the fruit spurs of the apple were initiated. Work on this project has not been conducted a sufficient length of time to supply information on the subject.

(c) *Summer Apples*. (Truck Station.) The variety orchard of summer apples at the Truck Station bore its first crop of any size this year. Notes and descriptions were taken on each variety.

EXPERIMENTAL WORK IN VEGETABLE CULTURE

1. *Investigational Work with Sweet Potatoes*. (Truck Station.) (C. D. Matthews and L. H. Nelson.)

(a) *Variety Testing*. It is the purpose of this work to determine the most desirable varieties of sweet potatoes for eastern North Carolina from the standpoint of productivity, market value, keeping quality, and quantity. There were 19 varieties under observation this year. The results were, in the main, confirmatory of the work of previous seasons. Certain varieties have proven their desirability while others have shown themselves to be undesirable.

(b) *Storage*. In connection with the variety work, storage tests are being made from year to year in the storage house to determine the behavior of the different varieties in storage. Certain varieties have proven themselves to be better keepers than others.

To facilitate the storage investigational work an additional curing room was constructed during the summer.

Investigations to determine the relation of time or digging to keeping quality, the relation of proper harvesting to keeping quality, the proper method of curing, and the correct management of the house, have been continued this season.

As a result of this work the division can authoritatively make recommendations regarding varieties for storage and the most desirable methods to employ in the management of the storage house.

(c) *Cultural Practices*. During the year work was conducted to secure information on the following different cultural practices:

The comparative value of slips vs. vine cuttings as regards productivity.

The effect of ridging on productivity and type of potatoes.

The effect of vine cutting on yield.

(d) *Seed Selection*. The following lines of work dealing with the seed selection of sweet potatoes were conducted during the year:

To determine the relative value of seed stock from high yielding and low yielding hills as regards productivity and uniformity of potatoes.

To determine the relative value of vine cuttings as compared with slips for maintaining yield and type, commencing from the same hill.

To determine the comparative value of large and small potatoes for seed.

To determine the comparative value of seed from late vine cuttings and seed from main crop draws as regards productivity, type, and keeping quality.

Very satisfactory progress should be reported on this project for this year.

2. *Investigational Work with Irish Potatoes*. (Mountain Station and Truck Station.) (C. D. Matthews, L. H. Nelson, and S. C. Clapp.)

(a) *Variety Testing* (Mountain Station). The testing of varieties of Irish potatoes to determine the most desirable varieties for Western North Carolina conditions was continued this year with 20 varieties. The testing has been in progress for a sufficient length of time to afford this division with the necessary information to make reliable recommendations regarding the choice of varieties for the western part of the State.

(b) *Variety Testing* (Truck Station). Satisfactory progress should be reported on the work to determine the most desirable early varieties for Eastern North Carolina and the best varieties for the second crop.

(c) *Hill and Tuber Unit Selection Work* (Mountain Station.) The hill and tuber unit selection method of variety improvement is being employed in an attempt to produce strains of the best varieties with greater productivity and more desirable characters.

(d) *Cultural Practices* (Truck Station). Work was conducted to determine the effects of different cultural practices on the yield of potatoes. Practices receiving consideration were:

Width of rows.

Distance apart in the rows.

Freshly cut or stored cut seed.

Effect of sprouting on yield.

Cut versus uncut seed.

(e) *Testing the Value of Different Sources of Seed.* Experiments were conducted to determine the comparative value of Maine grown seed, second crop seed produced in the Coastal Plain, and Western North Carolina seed in different stages of maturity as the most desirable seed for the early crop of Irish potatoes in Eastern North Carolina. This work has not been in existence a sufficient length of time to furnish conclusive results.

3. *Investigational Work with Cabbage.* (Mountain Station.) (C. D. Matthews, L. H. Nelson, and S. C. Clapp.)

(a) *Variety Testing.* The testing of varieties of cabbage to determine the most desirable varieties for Western North Carolina was continued this year. The testing has been in progress for a sufficient length of time to afford this division with the necessary information to make reliable recommendations regarding the choice of varieties for the western part of the State.

4. *Observation Garden.* (Truck Station.) (C. D. Matthews and L. H. Nelson.)

The all-year observation garden at the Truck Station has proven very valuable in supplying information regarding varieties and planting dates of different vegetables for Eastern North Carolina. It has been of value also as a demonstration in gardening and has been an inspiration to many visitors who have seen it.

Respectfully submitted,

C. D. MATTHEWS,
Acting Chief, Division of Horticulture.

Report of Horticulturist

To the Director:—I have the honor to submit herewith the report of the experimental work of the Department of Horticulture conducted at the State College during the year ending July 1, 1920.

The following change in personnel is to be noted: Mr. L. R. Detjen, Assistant Horticulturist for a number of years, tendered his resignation to become effective April 1, in order to accept the position of Associate Horticulturist in the Delaware State College and Station. Mr. Carlos F. Williams, of Darien, Conn., a graduate of the Pennsylvania State College, has been secured as Assistant Horticulturist, beginning July 1.

Research investigations in connection with Muscadine grapes which were begun by the North Carolina Experiment Station in 1907, continued to be the general subject of interest. The particular phase in hand during the year was that of the determination of the limits of hybridization of *Vitis rotundifolia* with related species and genera.

From time to time during the conduct of these investigations as a whole, various records of the work of previous investigators have been sought and consulted, and by observation a considerable amount of data

with respect to the behavior of this species when hybridized have been accumulated. It therefore seemed of advantage and fitting to bring these historical facts together in the form of a review of all known work that has been accomplished, and to collect and publish the results of such observations as had been made here, by way of an introduction to this specific problem, which looks toward not only the determination of the limits within which *Vitis rotundifolia* may be hybridized with other specific and genera, but also the outlining of a working scale of hybridization for the guidance of all who seek to improve this species of grape. This was done in the publication of two technical bulletins: No. 17, "The Limits of Hybridization of *Vitis Rotundifolia* with Related Species and Genera," and No. 18, "Some F. Hybrids of *Vitis Rotundifolia* with Related Species and Genera." The latter bulletin deals more particularly with the authenticity of certain so-called hybrids which have been under observation here for a number of years, and which by their characteristics gave rise to a question as to their true origin. The comparisons of these vines with large numbers of seedlings which are shown by descriptions and photographs prove quite conclusively that these so-called hybrids are really straight seedlings of *Vitis rotundifolia*. They do not exhibit any characteristics not possessed by that species.

Incidental to the investigation, but none the less important, is the matter of preserving whatever vines of special merit which may have been secured. These, when finally decided to be worthy of testing for introduction, should be thoroughly tried out in comparison with standard varieties grown for the purpose. This further work is beyond the limits of strictly research investigation and must be provided for elsewhere, possibly at the Pender Test Farm, where such work is in progress. Observations looking toward the final selection of individual vines for this purpose are being made at this time, and should be concluded by the end of the present growing season.

Respectfully submitted,

J. P. PILLSBURY,
Horticulturist.

REPORT OF THE DIVISION OF PLANT PATHOLOGY AND BACTERIOLOGY

To the Director:—In compliance with your request relative to the investigational work of this division for the fiscal year ending June 30, 1920, I beg to submit the following report:

TOBACCO DISEASES

The studies on this project which have been directed mainly toward a determination of the agencies involved in the initiation of tobacco wildfire in plant beds have shown that (1) the disease is seed borne through use of seed from infected pods: (2) that covers from old plant beds may be contaminated and (3) that the organism may overwinter in the soil. Wildfire in plant beds is spread by such agencies as man himself in weeding or in drawing plants, by flea beetles, and by rains. Many of these data, together with observations on other tobacco diseases, are recorded in "Some Diseases of Flue-cured Tobacco" (Bul. N. C. Dept. Agr., 4012; pp. 5-45; fig. 24, 1919).

SOYBEAN DISEASES

Two technical papers, "A Bacterial Leafspot of Velvet Bean" (Phytopath 10; No. 2, pp. 73-80, fig. 2, 1920), and "Bacterial Blight of Soybean" (Phytopath 10; No. 3, pp. 119-132, fig. 4, 1920), contain the results of the studies on this project. The former contains an account of a hitherto undescribed disease of velvet beans and cultural studies of the causal organism which is given the name *Aplanobacter stizolobii*. The latter presents the studies on soybean bacterial blight, a disease first observed in Nebraska in 1905. It has subsequently been reported from Connecticut and Wisconsin. The disease is fully described and its cause determined to be an organism, *Bacterium sojae*, not previously described. Infected seed are believed to be the chief means by which the disease is carried over winter and by which it is introduced into new localities. Infected leaves which remain in the field during winter have been found to harbor the parasite. The disease appears first on the cotyledons, spreads thence to the true leaves and by means of splashing rains is spread to nearby plants. While the manuscript for this paper was in press a report of bacterial blight of soybeans in Wisconsin (Jour. Agr. Res. 18: No. 4, pp. 179-194, Pls. 12-18, 1919) due to *Bacterium glycineum* appeared. During the coming year the results of a comparative study of these two blights and of the two species of bacteria will be published. Studies on various methods of seed treatment to prevent the disease are in progress.

OTHER INVESTIGATIONAL WORK

The studies on a little known vetch disease, mentioned in a previous report, have been completed and are in press. This disease was first col-

lected in New York in 1907 and the fungus which causes it described as *Protocoronospora nigricans*. It is now known to occur also in North Carolina, South Carolina, Georgia, Alabama, Mississippi, Louisiana, and Tennessee. The disease may be recognized by the presence of dark brown to black elongated lesions on any of the above ground parts of the plant. The diseased areas are especially characteristic upon the pods since they are oblique to the margin. The fact of greatest importance established by a study of the life history of the fungus is that the disease is initiated in new fields by the planting of infected seed. This has been demonstrated by its appearance on seedling plants in fields not previously seeded to vetch and by the occurrence of the fungus within the seed. Not all species of vetch are attacked with equal severity. Common vetch (*Vicia sativa*) and hairy vetch (*Vicia villosa*) become severely affected under conditions in which narrow leaved vetch (*Vicia angustifolia*) and *Vicia dasycarpa* remain practically free from disease. The cultivation of this last named species, instead of hairy vetch, gives promise of being a satisfactory way of combatting this disease.

Since, in the summer of 1919, injury to crops was occasioned by borax in certain potash salts, and since so little is known on the nature of borax injury and the amount required to cause injury to various crops, an investigation of the problem was begun in coöperation with the Division of Chemistry. The results of this work will appear in published form during the coming year in the Bulletin of the N. C. Dept. of Agriculture.

There has been isolated from cotton rootlets a fungus which has been made the basis of a mycological study. A complete report of this work under the title, "*Penicillium spiculisporum*, a new ascogenous fungus" will appear in *Mycologia* of the current year.

Some fundamental studies on the influence of hydrogen in concentration on culture media and on microorganisms are in progress and a preliminary report on certain phases of the work should appear during the coming year.

Since fragmentary notes comprise the available information on flagellation of legume nodule-bacteria, a study of this problem has been begun.

Certain selected strains of Turkey and Crimeon wheat have been found to be resistant in the Middle West to both stem rust and leaf rust, the latter of which diseases is very generally and very abundantly present in this State. The agronomic value of these resistant varieties is being studied in coöperation with the Division of Agronomy. The first year's results show that they possess very striking resistance, but are inferior in yield to varieties known to be adapted to this section. Seed from the crop of 1919 and several additional selections will be used in next season's tests.

ACKNOWLEDGMENT

Grateful acknowledgment should be made for the efficient services rendered by Mr. S. G. Lehman, who became Assistant Plant Pathologist September 1, 1919, and by Mr. I. V. Shunk, who was detailed by the Division of Chemistry of the State Department of Agriculture to aid in the investigations.

Respectfully submitted,

FREDERICK A. WOLF,
Chief, Division of Plant Pathology.

Notes on New or Little Known Plant Diseases in North Carolina in 1920

F. A. WOLF AND S. G. LEHMAN

The investigational work in botany has been centered on a few definite plant disease problems, but brief studies which are of more than passing interest have been made on several other diseases of plants. Certain of these appear worthy of permanent record and brief mention is therefore accorded them.

COTTON

Lightning Injury and Phoma. Our attention was directed in two cases, one near Lumberton and the other near Raleigh, to a sudden wilting and dying of cotton in small well-defined areas. A species of *Phoma* which appears to be identical with *Phoma corvina*, first collected in South Carolina by Ravel, a pioneer collector, was abundantly present on the stems of these plants. Further inquiry revealed the fact that the cotton became affected following a severe electrical storm and that lightning was beyond doubt the primary cause of the injury. The *Phoma*, which was fruiting in abundance within a week following the stroke, was not able to attack healthy uninjured cotton, as determined by isolation in pure culture and inoculation into normal plants. *Phoma corvina* is therefore to be regarded as a saprophyte or at most a weak wound parasite.

Root Mold—Penicillium spiculisorum. A new fungus to which the name *Penicillium spiculisorum* has been given (*Mycologia* 12: No. 5, pp. 168-174, Pl. 19, 1920) was isolated from cotton rootlets in the fall of 1919. In view of the fact that the fungus was obtained in a considerable number of cultures from more than a dozen plants, it was suspected of being able to penetrate living root tissue. Accordingly, during the past summer, cotton plants were grown in two jars of soil which, subsequent to sterilization, was inoculated with *P. spiculisorum* just prior to planting. When these plants had grown to a height of about two feet

portions of rootlets were used to reisolate the fungus. In order to eliminate surface contamination the rootlets were first thoroughly washed, to remove soil particles, were then immersed in 70 percent alcohol for five to ten minutes, and finally rinsed in sterile water. When planted in tubes of steamed rice a large proportion of the rootlets thus sterilized produced cultures of *P. spiculisporum*.

There was no external evidence, judged by the appearance of the above ground portions, that these cotton plants were diseased, but it indicates that the fungus is able to penetrate the peripheral tissues of the rootlets.

COWPEA

Pod rot (Choanephora cucurbitarum). Previous studies at this station (Jour. Agr. Res. 8, No. 9, p. 319-328, Pls. 85-87, 1917) direct attention to the occurrence of this organism on squashes, cucumbers, okra, cotton, althea, and scarlet hibiscus. A recent report (Ann. Bot. 34, No. 135, pp. 399-403, Pl. XIX, 1920) states that the same organism attacks chillies (*Capsicum* sp.) in India. During the past summer it was found to cause a rotting of cowpea (*Vigna sinensis*) pods in fields near Raleigh. Fading flowers were also involved in decay, but entrance to the pods does not appear to have been gained through these flowers. A protracted rainy season appears to be a factor favorable to the occurrence of pod rot.

LIMA BEAN

Pod Blight (Diaporthe phaseolorum). Specimens of this disease on pods were received from Fayetteville during the past summer with the note that it was causing the pods to fail to fill. Pod-blight appears to have been collected only once previously within the State, in 1913, at Faison. The disease has been reported from New Jersey, Connecticut, Maryland, and Virginia, but appears to be of rare occurrence.

FIG

Anthrachnose (Glomerella cingulata). Anthracnose has been the cause of a rot of fruits and of considerable defoliation of figs near Elizabeth City. This disease was first collected in 1909 in the eastern part of the State and its cause described as *Colletotrichum carica*, a new species of fungus. It has subsequently been shown that the causal organism is identical with the organism causing apple bitter rot and which is capable of causing in addition a diseased condition in a wide variety of plants. Isolations of the conidial stage have given rise to the ascogenous stage when cultured on glucose agar.

PEPPER

Soft rot of pepper fruits (Pythium de Baryanum). During the rainy weather of July a new disease was found on cultivated sweet peppers. The disease has been found only on fruits, and natural infection has

always occurred on peppers not more than six or eight inches above the ground. The disease appears first as a small water-soaked spot at the point of inoculation. The infected area enlarges, rapidly becoming soft, watery, slightly sunken and somewhat lighter in color in contrast with the surrounding green uninvaded tissue. The parasite soon invades the particular locule in which infection has occurred and within a period of four or five days permeates the entire fruit, causing a soft, wet rot, with a brown surface discoloration. The epidermis remains unbroken and the discolored and misshapen fruit clings to the plant for several days. The disease has caused but little loss and was checked by dry weather. A complete study of the causal organism will appear in a separate report.

SOYBEAN.

Mosaic. This name is applied to a characteristic mottling of the foliage of various plants, whose cause is little known further than that it is specific with respect to certain species or closely related species of plants and is highly infectious. The garden bean is the only leguminous crop affected by mosaic to any serious extent. Mosaic of peanuts has been reported once from Virginia. The present report of soybean mosaic from Oxford appears to be the first record of mosaic on soybeans. A portion of the foliage on each of several plants was noted to be affected and no studies were made of the relationship of the disease to mosaic of other legumes.

Anthraxnose (Glomerella cingulata). About September 1 a number of soybean plants were found in the field whose pods bore lesions which were encrusted with conidia of a fungus belonging to the genus *Colletotrichum*. Pure cultures of this organism on sterile soybean stems and nutrient agar produced numerous perithecia containing asci and ascospores. Dr. C. L. Shear, to whom a culture of the organism was submitted, identified it as *Glomerella cingulata*.

The season had advanced so far at the time the disease was found that after the fungus had been isolated, one attempt only at artificial inoculation in the field could be made. This trial gave negative results, due possibly to the hot, dry weather extant at the time. Ascospores when sown on green soybean pods in moist chambers resulted in abundant infection.

This occurrence of *G. cingulata* on soybean is of interest since one other legume, sweet pea, is known to be attacked by it.

Phoma blight (Phoma sp.). As the soybeans on the Plant Breeding grounds of the station approached maturity, certain of the early maturing varieties were noted to be affected with a blight which involved the stems and pods. At first isolated plants only were diseased, but the infection gradually involved others. A species of *Phoma*, as yet undetermined, was fruiting in abundance upon the affected parts. Since no species of *Phoma* are known to occur on this host, isolations have been

made in order to determine its pathogenicity and identity. One series of inoculations made in the field during a protracted dry period has resulted in failure to secure infection. Because of the importance of soybeans within the State it is planned to pursue the study of this disease next season.

TOMATO

Buckeye rot (Phytophthora terrestris). This disease was definitely identified in North Carolina for the first time during the past summer when it appeared in gardens in West Raleigh. The organism produces a dark discoloration, accompanied by a rather firm decay of the peripheral tissue of tomato fruit. This decay is further characterized by the presence of concentric zonation. The disease made its appearance and did its greatest damage during the rainy weather of July and August. With the passing of the rainy season the disease disappeared. Damage in some gardens was confined to a few fruits only, while in others the loss amounted to fully 20 per cent of the crop produced. The organism was grown on infected tomato fruits and microscopic observation made on the structure of conidiophores and on the germination of the zoösporangia.

VETCH

Downy Mildew (Peronospora viciae). A single collection of this disease was made near Raleigh on *Vicia angustifolia*. All of the above ground parts were involved and were uniformly covered with a downy gray coating. Although the disease has been reported from both Europe and America, it appears to be local in its distribution and of rare occurrence.

REPORT OF THE DIVISION OF MARKETS AND RURAL ORGANIZATION

To the Director:—This report is for the year ending December 1, 1920, and covers the investigations of the Division of Markets and Rural Organization, conducted jointly or separately by the North Carolina Department of Agriculture and the North Carolina State College of Agriculture and Engineering, in coöperation with the United States Department of Agriculture under the agreements and plans entered into by these institutions for the conduct of all agricultural work of this kind in the State.

LIVESTOCK

Eggs and Poultry.—Investigations and observations made at previous times show there is a decided need for a more remunerative plan of marketing eggs and poultry. This is more especially true in the Piedmont and western sections of the State that are more distant from some of the larger cities. In the eastern section of the State large quantities of both eggs and poultry are shipped to the Norfolk market by farmers themselves. Consequently they have a fairly good market. However, if they would produce a higher quality product they could well afford to ship further north, where their produce, especially the eggs, would command a higher price.

In the Piedmont and mountain section practically all of the poultry and eggs are sold locally, either at stores, to dealers, or to produce wagons in some localities. As is to be expected when sold in this way farmers do not get what they should for their products. It is known that some of the produce dealers in that section are making very handsome profits. There is a decided need for poultry and egg marketing circles in that section.

Cattle.—During the fall of 1919 a fairly complete list of the feeder and stocker cattle for sale in the western part of the State was prepared and distributed among cattle feeders, butchers, county agents, and other interested parties, for the purpose of assisting in the movement of these cattle. A considerable number of cars were placed in this way. However, because of roughness of the county it is almost impractical for cattle feeders from eastern counties to go to the cattle growers in the mountain sections for their cattle and consequently in the past most of them have been buying through dealers.

In an attempt to remedy this situation, a cattleman's association, composed of the growers of feeder and stocker cattle in Avery, Mitchell, and Yancey counties, was formed early this season and plans were made for holding a coöperative sale of feeder and stocker cattle at Spruce Pine on September 23d. At this sale cattle from three counties were assembled and sold at private sale. About 700 cattle were included in this sale.

Some interest is being manifested in the coöperative shipment of cattle

and some of this is being done, but only in a limited way. It is quite probable that there will be a gradual increase in the number of cattle sold in this way when they are in market condition. It now seems, however, that the sales plan above outlined is the most practical plan of selling feeder and stocker cattle, as no regular feeder and stocker cattle market is available.

Considerable personal assistance was given in the sale of fat cattle during the spring of 1920. As a rule this class of cattle has been going largely to northern markets, but this year a surprisingly large per cent of them have been bought by butchers in the State. This is a very good indication that there is a growing demand for the better grades of beef. In many instances the prices obtained for these fed steers have been from $\frac{1}{2}$ to $1\frac{1}{2}$ per cent per pound above northern markets, freight and "drift" considered. However, in spite of these prices, most cattle feeders lost money on feeding this year.

Hogs.—Coöperative hog shipping work was instituted in a number of counties, making a total of 11 counties in which this work is being carried on. There is really no surplus of hogs in the State, although local markets will frequently force local prices down during the height of the hog marketing season, unless arrangements are made among farmers to market their hogs coöperatively. A number of definite examples have been seen of the value of coöperative marketing in stimulating local markets. In other instances local prices have advanced from one to two cents a pound where coöperative marketing have been submitted to farmers of a county, even though no shipments were actually made.

Another value of coöperative shipping is that it causes farmers to see that local markets do not have to be depended upon and in this way stimulated production.

Fortunately for farmers in the eastern counties of the State most of their local markets and some of their larger markets to which they shipped dressed hogs by express do not discriminate against soft hogs, so in that way they frequently get more for them than if shipped to the Richmond and Baltimore markets. About 95 per cent of the hogs raised in the eastern part of the State are soft, being fattened on either soybeans or peanuts. Practically all local markets west of Raleigh discriminate against soft hogs. In fact it is almost impossible to sell them in that section of the State. Markets in that section of the State also discriminate very strongly against the Duroc Jersey hog, claiming it produces too much lard, which they cannot use profitably. Not infrequently they will pay from one to three cents per pound more for Berkshire or Poland China hogs. In some instances this discrimination is justified on the fresh meat market, as there are a large number of short chunky Duroc hogs in the locality referred to. However, the more growthy type is rapidly growing in favor among farmers.

Coöperative hog shipments are carried on largely through county agents as there is hardly enough surplus hogs in a county to justify a

shipping association. County agents have taken considerable interest in this work, and if there was any considerable surplus of fat hogs there seems no doubt but that it would very readily be taken up through coöperative marketing.

Lambs.—The coöperative lamb marketing work instituted in six counties of the State during the summer of 1919 was the first time work of that sort had been undertaken. The results were, on the whole, very satisfactory. Only one additional county made a shipment this summer. Most of the lamb crop goes to market after July 1st. Baltimore, Philadelphia, and Jersey City are the three markets patronized. As yet the Richmond market handles only a limited number of lambs. While all shipments go to one of the three markets mentioned this makes a rather long haul from some of the western counties in the State, and consequently, a nearer market would be greatly appreciated by sheep men and dealers. During the past year there has been a marked increase in sentiment favoring the coöperative marketing of lambs and it seems quite probable that there will be a steady increase in the number of sheep and lambs sold that way.

Wool.—In the summer of 1920 plans were made for holding three district coöperation wool sales in the State. One was to be at Asheville, in the mountain section, another at Greensboro, in the Piedmont section, and a third at Washington, in the coastal section, thus having them so located that wool from all over the State could easily be assembled at one of the three points.

Circular letters were mailed out to approximately 4,000 sheep growers in the State calling attention to these sales, and inviting them to list their wool for sale. Sheep growers from a large per cent of the counties listed wool. The sales were to have been held in the latter part of August and the forepart of September.

Because of the demoralized condition of the wool market arrangements were made with one of the larger woolen mills in the State that, in case a satisfactory bid was not received for the wool in the sales they were to take the wool and make it up into blankets at a minimum charge and return the blankets to the original consignors of the wool.

Because the wool market failed to improve the sales were all called off and instructions were sent the wool growers for consigning their wool to Elkin to be manufactured into blankets. A considerable part of the wool holdings were thus converted into woolen cloth, yarns, and blankets and returned to the consignors to dispose of as they saw fit. Few of them had any surplus for sale. The cost of manufacturing a pair of double blankets, 72 x 84 inches, was \$5.00 and the average amount of unwashed wool required was approximately twelve pounds. Depending upon the quality of the wool, three grades of blankets, ranging in wholesale value from 12.00 to 16.25, could be manufactured. The bulk of the North Carolina wool made the medium grade blankets, worth 14.25 at wholesale.

This method of disposing of the wool was very satisfactory, except, perhaps, to a few of the larger sheep growers, who are preparing to hold their wool in anticipation of a better market later. A number of Missouri farmers were permitted to consign wool to the Elkin mill on the same plan.

PERISHABLES

The work in marketing perishables is under the supervision of Mr. Gorrell Shumaker and assistant. This department has been very active during the year and has done very creditable work.

Cowpeas and Soybeans.—During the early months of the past winter a survey of the supply of the soybeans and cowpeas available for seed purposes disclosed a serious shortage. Growers were warned of this fact and those who had not sold hastily were rewarded with an increase in price of more than two dollars per bushel. The growers were permitted to advertise their seed in the Farmers' Market Bulletin, provided they were willing to guarantee purity of variety and germination quality and the surplus soon found a ready sale. Many of those who sold early did so because of a lack of storage facilities. Coöperative warehouses would enable these growers to hold their seed in good order for the higher prices prevailing just before the spring seeding. The warehouses would also permit the use of grading and cleaning machinery, resulting in the sale of better seed as well as an increase in the price to the growers.

Federal reports indicate that the 1920 seed crop just harvested is no heavier than the 1919 crop, even though it was expected that the high prices paid for seed last year would induce growers to cut down acreage used for forage and to increase the acreage allowed to mature for the seed crop. From these facts it would seem that another survey, similar to the one made last season, should be of value to North Carolina growers. The idea would be to locate surplus seed stock yet in the hands of the growers in an effort to determine the approximate percentage sold to dealers in seeds at the harvest season.

Sweet Potatoes.—The 1919 crop of sweet potatoes forced many North Carolina growers to find a market outside of the State for their surplus stock. Before this time Catawba County was practically the only section to ship to the more distant markets. It is doubtful if even the 1919 crop was really in excess of the State's need, the problem being one of distribution. The growing popularity of the storage houses in certain sections has made possible better keeping conditions, and these neighborhoods may possibly be over-supplied with market stock, but there are so many other sections where the most of the sweets rot in the bank storages. It is believed, therefore, that no great quantities need be shipped north were facilities for local distribution given better attention.

The 1920 crop for this State is reported to be heavy and under these circumstances we may be forced to cater to the northern markets. In this

case our growers have the advantage of the experiments of the more southern states last season, for they shipped considerable quantities of the southern sweets into the northern markets, thus familiarizing the trade there with the most delicious qualities of this commodity, and thereby paving the way for a much greater demand this season.

A study of several cars shipped from this State to northern markets during the past season proves conclusively that it is not safe to ship bank-stored sweets any great distance. They rot very badly even in short hauls if the cars are not well ventilated. Studies of storage houses have indicated that good marketable stock will keep in excellent condition, provided the principals under which the storages operate are not overlooked. Failure to comply with storage house rules caused a loss of about 30 per cent in one of the larger North Carolina storages during the past season.

In order that shipments to northern markets from this State might be uniform in quality and condition the revised sweet potato grades as recommended by the Federal Bureau of Markets were adopted as the legal standard for North Carolina. Southern sweet potato growers have a good opportunity on northern markets provided they ship a good quality article at all times.

Mountain Products—In addition to the work with sweet potatoes and apples, some attention has been given to grades and packages for bunch grapes and plans are under way to include cabbage as soon as possible. Both potato grades and apple grades, as recommended by the U. S. Department of Agriculture have met the approval of the growers and have been adopted as the legal standard for North Carolina.

Mountain potato growers are being advised either to sell at digging time or to build coöperative warehouses along railroad sidings. A study of past results indicates that on an average the growers selling at harvest time make the most money. The crop comes in ahead of the bulk of the northern crop and hence it has less competition. Prices may be higher during the winter, but at that time it is impossible to dig the potatoes from the bank storages. A little later the thaws come and then it is impossible to haul over the mountain roads. When the roads dry out it is warm enough to permit heavy movement from all the leading northern and western producing sections, and hence the North Carolina potato goes on the spring market in competition with the product from other sections where growing costs are materially lower. Should the growers store in commercial houses along sidings they might take advantage of the high prices during the winter and when competition from other sources is practically impossible.

Apple growers are being urged toward improved grading and packing methods. The unusual quality and color of North Carolina apples makes them especially suitable for the fancy trade, but extreme care must be used in packing, grading, and sizing this class of fruit. So many growers still spray carelessly, or not at all, that the apple industry is not what it might be, considering our wonderful natural advantages.

The first Western North Carolina Apple Show, recently held at Asheville (October 27, 28, 29), was a revelation to those who attended. The show was successful not only as an educational exhibit, but as an advertising medium as well.

The southern market rightfully belongs to North Carolina apple growers, but in the past many of them have flooded these markets with inferior or ungraded fruit, thus seriously curtailing the demand for all North Carolina fruit. In the meantime the dealers have been purchasing more and more of western and northern fruit and it is only by putting on the market a distinctly superior pack that our growers can gain prestige in this section. Our uniform State grading system should make this possible.

FRUIT AND TRUCK MARKETING ASSOCIATION

During the past year the Division of Markets has assisted in the organization of two coöperative associations of peach growers, a truckers' association, the State Horticultural Society with its separate marketing organization, an association of apple growers, and a soil improvement association. The latest demand for assistance comes from the cantaloupe growers of the Laurinburg section. They will grow 600 to 1,000 acres in 1921.

Organization of potato, apple, and cabbage growers are needed all over the mountain counties. In this section coöperative cold storages on railroad sidings would facilitate the marketing of enormous quantities of perishable products which at present never reach a market.

STANDARDIZATION OF GRADES AND INSPECTION SERVICE

Meetings have been held at important producing sections with an idea of discussing with the growers what requirements should be included in the grading standards for various products. Already the grades as recommended by the U. S. Department of Agriculture have been adopted as the legal standard for North Carolina strawberries, potatoes, sweet potatoes, and apples. Studies of grades for peaches and grapes are contemplated. Numerous meetings have been held to explain and demonstrate the various grading standards.

Studies have also been made of the many types of containers in use in this State and the better types have been endorsed through speech, demonstration, and the press.

Considerable improvement has been made in the grading and packing as a result of the 1919 inspection work. Because of a serious shortage of men in the division this work has been handicapped during 1920. A member of this division served as inspector for the Chadbourn strawberry belt and local inspectors for potatoes at Mount Olive and Bethel were appointed. This work cannot be continued in full swing, however, until additional help is secured.

EXHIBITS

Two fair exhibits were installed during the year. The first of these consisted of a three-booth exhibit at the State Fair. One booth featured cotton warehousing and the State warehouse system, another the use of the truck as the ultimate solution of the short haul, and the third booth was divided between mechanical sizing of fruit and coöperating marketing of wool through blankets. The second exhibit was at the W. N. C. Apple Show, at Asheville. Here again we featured wool marketing and rural transportation. Transportation difficulties prevented the exhibiting of the mechanical fruit sizer constructed for that show. A great amount of interest was manifested by visitors in both these exhibits. A much more elaborate exhibit and a grading and packing demonstration should be planned for the 1921 Apple Show.

PUBLICATIONS

In addition to the market news service work this division has issued market circulars and bulletins as follows:

Farmers' Market Bulletin, issued monthly.

Weekly Price Report.

Weekly Hog Market Quotations (November to June).

Monthly Review of Producers' Prices (discontinued since April).

Monthly Financial Statement of North Carolina Credit Unions.

Circular on Harvesting, Grading, and Packing Peaches.

News articles on Cotton Grading, State Warehouse System, Grade and Package Standardization, and Peanut, Livestock, and Potato and Wool Markets.

There are two fields of activity in marketing which are at present not receiving adequate attention from this division, the marketing of tobacco and the marketing of so-called field crops. With regard to the tobacco situation it is becoming apparent that the next probable step will be the development of a tobacco warehouse system similar to the cotton warehouse system. But before we reach that stage much preliminary work will have to be done in the way of investigation, education, and organization. I, therefore, recommend that authority be given for the appointment of a specialist in tobacco marketing for these purposes.

With regard to field crops this has been, it appears to me, a somewhat neglected field of opportunity. There has been much talk of a reduction of the tobacco and cotton acreage. From both the marketing and farm management points of view, I am quite sure that this is the proper thing to do. But a reduction of cotton and tobacco implies an increase of production along other lines, livestock, field crops, etc. In other words, when we are stimulating the production and aiding in the marketing of field crops we are indirectly aiding in the reduction of cotton and tobacco. I, therefore, recommend that authority be given for the appointment of a specialist in the marketing of field crops, whose duty it shall be to im-

prove methods in the marketing of field crops, to coöperate with the U. S. Bureau of Markets in the marketing of grain and other field crops, and to carry out the provisions of the North Carolina Act of 1919, establishing standards for agricultural products, so far as this law relates to him as a member of this division.

Respectfully submitted,

B. F. BROWN,
Chief, Division of Markets and Rural Organization.

REPORT ON DRAINAGE

To the Director:—This report is for the year ending November 30, 1920, and covers the investigational and experimental work on Drainage, conducted under a coöperative agreement between the North Carolina Department of Agriculture and the United States Department of Agriculture.

The investigational and experimental work is connected somewhat with the extension work, since much of the material and many of the locations for experiments are obtained as a result of extension work.

Mr. F. O. Bartel has continued as drainage engineer for the N. C. Department of Agriculture throughout the year.

The strictly experimental work may be classified and summarized as follows:

RUN-OFF DATA ON DRAINAGE CANALS

The gaging station for the determination of run-off on Third Creek Canal, Iredell County, is still being maintained. Records of gage heights are complete from March 17, 1913, to date. Since July 1, 1919, the rainfall on Third Creek watershed (44,000 acres) has been recorded at six stations. All data have been compiled and summarized to June 30, 1920, in report form. Briefly the results of the experiments to date indicate—

1. A run-off factor of one inch in 24 hours over the watershed should be adopted in the design of drainage ditches in Piedmont North Carolina.
2. The average annual run-off on Third Creek is approximately 43 per cent of the average annual rainfall.
3. The daily rainfall recorded at one station on a watershed does not represent true daily rainfall conditions. To obtain an approximate true rainfall it is necessary to average the rainfalls of several stations scattered over the watershed.
4. For small watersheds with rainfall conditions as they are on Third Creek, one rainfall station for each 10 square miles of watershed is apparently not too frequent.

STUDY OF EFFICIENCY OF UNDERDRAINS

The purpose of these experiments is to determine:

1. Amount of run-off from underdrained land.
2. Relation of run-off to rainfall.
3. Action of tile drains in lowering the ground water level.

Cotton Valley Farm.—The experiments started in November, 1916, on two tile drainage systems at this farm in Edgecombe County were concluded on December 31, 1919. All data have been assembled and a report prepared. The soils on the tract investigated are known as second terrace deposits and are common to the second bottom lands along many of the rivers in the eastern part of the State. In an area of 200 acres twelve different soil types were identified, but the texture of the soil is even more

variable. The results obtained represent what may be expected from the underdrainage of nonhomogeneous soils.

Briefly, the results may be summarized as follows, bearing in mind that they can only safely be applied to areas where soil conditions, topography, rainfall, and climate are similar to those studied:

1. The texture of the soil is the controlling factor in the efficiency of tile drainage. The spacing of the drains should be such as to suit average soil conditions as near as they can be determined.

2. Before designing drainage systems in nonhomogeneous soils, frequent borings to a depth of three feet should be made to determine the soil textures.

3. In general, laterals should be arranged in parallel, straight lines at equal distances apart and at the same average depth. The minimum economic spacing recommended is 60 feet, and the maximum depth 3 feet.

4. A run-off factor of $\frac{1}{4}$ inch in 24 hours from the underdrained area is ample to use in the design of the mains and submains.

5. The minimum grade recommended for the drains is 0.20 per cent ($2\frac{3}{8}$ inches fall per hundred feet): if flatter than this the joints between tile should be protected against the entrance of silt.

J. T. Lewis Farm.—Experiments similar to those conducted at Cotton Valley Farm were started at this farm, located in Pitt County, in April, 1919. The experiments are still in progress. The data have been summarized to June 30, 1920, and a progress report prepared. The soil is homogeneous in character and belongs to the Norfolk and Portsmouth series. Briefly, the results obtained to date may be summarized as follows:

1. The Norfolk and Portsmouth sandy loam soils are of an open nature and respond almost immediately to tile drainage if an outlet for the water is provided.

2. A spacing of 120 feet and depth of $3\frac{1}{2}$ feet may be adopted for tile laterals in these soils.

3. The economic rate of run-off to be adopted for underdrainage systems on areas similar to the one under investigation appears to be between $\frac{1}{4}$ and $\frac{3}{8}$ inches in 24 hours from the underdrained area.

4. Most of the drains on this tract have a grade of 0.30 per cent or more and all are apparently in good working order, indicating that there is no danger of 4-inch tile silting up on grades of 0.30 per cent or more.

Black Land Station.—This farm, owned by the N. C. Department of Agriculture, is located in Washington County, in the muck soil area of that section, formerly a swamp. Approximately 100 acres of this farm are underdrained with tile spaced 330 feet apart at a minimum depth of four feet, the tile resting on the clay subsoil. In January, 1920, 69 wells for determining the action of the underdrains in lowering the ground water level were installed on this farm.

The experiments are still in progress. It is yet too early to draw any definite conclusions from the experiments, except to state that it is apparently impossible to overdrain these muck soils. Tile operate successfully on a grade of 0.04 per cent ($\frac{1}{2}$ -inch fall per hundred feet) in the clay subsoils of this section.

In addition to the above classified lines of work, various special investigations and studies have been made.

Respectfully submitted,

H. M. LYNDE,
Senior Drainage Engineer.

